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THE ANTISEPTIC TREATMENT OF WOUNDS

MANUAL

OF THE

ANTISEPTIC TREATMENT

OF WOUNDS

FOR STUDENTS AND PRACTITIONERS

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BY

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PREFACE.

THE present manual is written with the view of enabling students to obtain a thorough knowledge of the practical details of the best methods of treating Wounds. It is not, however, intended in any way to be a substitute for the larger works on Antiseptic Surgery; for without a thorough knowledge of the scientific basis of wound treatment, of its development as shown by its history, and of what it can do, the best results are not likely to be obtained, nor can progress be made. In the introductory chapters I have treated of matters which were not ripe for discussion when my work on Antiseptic Surgery was written; and thus I hope that the two volumes will furnish the reader with as complete a view of the subject as is possible at the present time.

W. WATSON CHEYNE.

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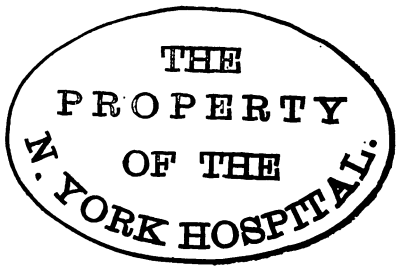
January 1885.



CONTENTS.

CHAPTER I.

REPAIR AND DANGERS OF WOUNDS.

PAGE

Processes of repair—*Healing by first intention—Healing by scabbing—Healing by granulation—Healing by union of granulations—Healing by organisation of blood-clot*—Comparison of course of simple and compound fractures—Dangers which may follow wounds 1

CHAPTER II.

BACTERIA AND DISEASE.

General description of bacteria, their origin and life history—Causes of septic intoxication—Inflammation and suppuration—Acute osteomyélitis—Erysipelas—Gangrene—Pyæmia—Septicæmia 11

CHAPTER III.

DESTRUCTION OF BACTERIA.

Experiments on disinfectants, carbolic acid, bichloride of mercury, &c.—Principles of wound treatment—Aseptic and antiseptic surgery 25

CHAPTER IV.

ASEPTIC SURGERY—MATERIALS EMPLOYED.

PAGE

Problems to be solved in order to keep a wound aseptic: Carbolic acid—*Carbolic lotions—Pure carbolic acid—Solution in methylated spirit—Carbolic oil—Carbolic acid and glycerine*: Spray producers: Catgut—Carbolised silk: Protective: Carbolic gauze—Macintosh: Sponges: Boracic acid—*Boracic lotion—Boracic lint—Boracic ointment*: Salicylic acid—*Salicylic acid cream—Salicylic ointment*: Chloride of zinc: Iodoform: Carbolised cotton wool 36

CHAPTER V.

ASEPTIC SURGERY (*continued*).

Example of an aseptic operation: Purification of the skin—Fingers—Instruments: Spray—Precautions—Probable errors, and mode of remedying them: Guard: Ligature of arteries: Drainage of wounds—India-rubber tubes—Catgut drains—Horse hair—Decalcified bone tubes (Neuber's and MacEwen's): Sutures: Button stitches—Stitches of relaxation—Stitches of coaptation—Aseptic strapping—Protectic: Deep dressing: Loose gauze: Gauze dressing: Elastic bandage. CHANGING THE DRESSINGS—Time—Method. TREATMENT OF ULCERS—Purification of the sore: Boracic dressing: Boracic and salicylic ointment: Boracic poultice 46

CHAPTER VI.

ASEPTIC SURGERY (*continued*).

Special dressings: *Head dressings: Neck dressings: Breast dressings—Abscess of mamma—Excision of mamma alone—Excision of mamma and axillary glands: Axillary dressings: Dressings on the limbs: Dressings for psoas abscess: Lumbar abscess: Hip-*

PAGE

joint abscess: Dressings in cases of hernia and operations on the scrotum: Excision of joints. Aseptic treatment of abscesses. *Chief points to be considered in opening abscesses—Method of opening abscesses—Drainage of abscesses—After-treatment of abscesses—Empyema—Perineal and anal abscesses.* Treatment of wounds produced accidentally: *Problem to be solved—Purification of wound—Further treatment of the wound.* Special wounds: *Compound fractures: Wounds involving tendons, nerves, &c.: Wounds of joints: Compound fractures of the skull: Penetrating wounds of the thorax: Wounds of the abdomen.* Putrid sinuses and wounds. Treatment of burns. Treatment of gangrene. Treatment of nævi and varicose veins . . . 77

CHAPTER VII.

ASEPTIC SURGERY—MODIFICATIONS.

Country practice: *How to dispense with the spray during the operation—and during the after-treatment: How to render the dressings less frequent*: Is the aseptic method applicable in war? *Sir Joseph Lister's suggestions: Esmarch's plan: Reyher's method* 103

CHAPTER VIII.

ASEPTIC SURGERY (*concluded*).

Other methods of carrying out aseptic surgery. Substitutes for carbolic acid: *Salicylic acid: Neuber's permanent dressings: Thymol: Acetate of alumina: Eucalyptus oil: Bichloride of mercury: Naphthalin: Iodoform*: Aseptic surgery by filtration of the air. Subcutaneous surgery 112

CHAPTER IX.

ANTISEPTIC SURGERY.

Treatment by antiseptics: *Carbolic acid—objections to it: Chloride of zinc: Boracic acid: Sulphurous acid: Chlorinated soda:*

PAGE

Alcohol—Hutchinson's method: Terebene and Sanitas—Bilguer's method—Neudörfer's salicylic powder. Free drainage as an antiseptic method. Irrigation and immersion. Open method: *Modes in which it acts antiseptically: Bartscher and Vezin's method: Burow's method: Rose's modification.* Healing by scabbing: *Methods of forming a crust: Bouisson's ventilation method: other modes.* Guérin's cotton-wool dressing. Modes in which the destructive action of the tissues on bacteria is assisted. *Why does not fermentation always occur in the blood in wounds in which organisms are present? Best practical methods* 125

INDEX 145

LIST OF ILLUSTRATIONS.

FIG.		PAGE
1.	Common forms of bacteria	11
2.	Section of kidney, showing plug of micrococci surrounded by a clear necrotic layer, and outside this a ring of inflammatory tissue. The poisonous material produced by the micrococci when strong kills the tissue, when more dilute sets up inflammation	18
3.	Section of kidney, showing in the upper corner a mass of micrococci, a clear necrotic ring and a layer of inflammation, as in fig. 2. In the centre is the further stage of the process: the inflammatory cells and the micrococci have now infiltrated the necrotic ring, and an abscess is the result. (For further details as to figs. 2 and 3 see 'British Medical Journal' for September and October 1884)	19
4.	Section of skin at the spreading margin of the redness in erysipelas (from a photograph by Koch, x. 700). A lymphatic vessel is seen containing micrococci, which are also spreading into the tissues around	21
5.	Hand spray producer	38
6.	The ordinary steam spray producer	39
7.	Steam spray producer, showing the lamp at present in use	40
8.	Large steam spray producer with double nozzle for ovariotomy &c.	41
9.	Trough for catgut	41
10.	Lister's pocket catgut holder	42
11.	Porcelain trough containing instruments soaking in carbolic lotion	49

FIG.		PAGE
12.	General arrangement of surgeon, assistants, towels, spray, &c., in an operation performed with complete aseptic precautions	51
13.	To show the arrangement of towels, &c., in a large operation	52
14.	Method of tying vessels in dense tissues (after MacCormac)	55
15.	Another method of tying vessels in dense tissues (from Esmarch)	55
16.	Ordinary oblique-ended drainage-tube ready for use	57
17.	Drainage tube with masses of gauze in the loops of thread	57
18.	Incision for inguinal hernia, stitched, showing the position of the drainage-tube at the outer angle of the wound	58
19.	Sinus forceps	59
20.	Catgut drain ready for insertion	60
21.	Mode of using catgut drain as shown in operation for stretching the sciatic nerve	61
22.	The same wound stitched	62
23.	Method of preparing a horse-hair drain for re-introduction	64
24.	Lead buttons for deep stitches	65
25.	Wound after removal of mamma and axillary glands, stitched	66
26.	Excision of the hip joint. Wound stitched; protective and deep dressing applied	68
27.	Dressing in a case of psoas abscess opened above Poupart's ligament	70
28.	Method of changing a psoas abscess dressing	72
29.	To illustrate the general arrangement of dressings on the neck	78
30.	To show the arrangement of the turns of bandage on the head seen from above	79
31.	Dressing applied in a case of abscess of the mamma (breast dressing No. 1)	79
32.	Breast dressing No. 2	79
33.	Dressing after excision of the mamma	80
34.	Dressings applied after excision of mamma and axillary glands, to show the arrangement of the dressings and bandages	81
35.	Binder applied outside the dressing represented in fig. 34, so as to keep the parts and dressing at rest	82

FIG.		PAGE
36.	Dressing in cases of operation on the axilla alone	83
37.	Dressing in a case of psoas abscess opened above Poupart's ligament, seen from the front	84
38.	Psoas abscess dressing (fig. 37), seen from behind	85
39.	Dressing in a case of lumbar abscess, seen from behind	86
40.	Dressing in a case of hip-joint abscess, with elastic applied	87
41.	Deeper part of the hernia and scrotal dressings	87
42.	Dressing in a case of operation for hernia, or on the scrotum on the left side, showing the arrangement of the dressing and elastic bandage	88
43.	Dressing in hernia cases or in operations on the scrotum, showing the arrangement of the bandages in the perineum, seen from below	89
44.	Splint for excision of knee, ready for application	90
45.	Splint applied in a case of excision of the knee	90
46.	Two forms of sharp spoons, a large round one and a small oval one	100
47.	(from MacCormac) Esmarch's first dressing for the wounded in battle	108
48.	Thiersch's champagne bottle irrigator	131
49.	Arrangement for irrigation in the upper limb (after Esmarch)	132
50.	Arrangement for irrigation in the lower limb (after Esmarch)	133
51.	Apparatus for continuous immersion (after Esmarch)	134

THE

ANTISEPTIC TREATMENT OF WOUNDS.

CHAPTER I.

REPAIR AND DANGERS OF WOUNDS.

Processes of repair—*Healing by first intention—Healing by scabbing—Healing by granulation—Healing by union of granulations—Healing by organisation of blood-clot*—Comparison of course of simple and compound fractures—Dangers which may follow wounds.

In order to carry out the treatment of wounds with intelligence, it is essential to have clear ideas of the process of repair, of the evils which may follow wounds, and of the cause of these evils. The repair of injuries is well discussed in surgical text-books, but in the present manual it is necessary for the sake of completeness to give a short sketch of the subject.

If an incision be made in a frog's foot and the wounded part observed under the microscope, it will be seen that the layer in the immediate vicinity of the injury is in a state of intense inflammation. In the immediate neighbourhood the circulation is arrested and the movement of the pigment has ceased. At the margin of the stasis the blood passes through the capillaries slowly and with difficulty, while the blood-vessels in the neighbourhood are dilated, and there is there increased flow of blood. The inflammation goes on to exudation of serum and migration of corpuscles, and then the process subsides and repair commences. The same thing happens in the case of wounds in man. The passage of the knife through the

tissues sets up an intense inflammation in a microscopic layer of the whole surface of the wound. This results in the exudation of liquor sanguinis which coagulates, and of white corpuscles which become entangled in this coagulated liquor sanguinis; in other words, the surface of the wound becomes covered with lymph. If no other irritating cause comes into play the inflammation does not go further: retrogression occurs; blood begins again to flow freely in the capillaries in which the circulation was previously interfered with; the cells in the lymph probably multiply and form fibrous tissue and new blood-vessels; the coagulated liquor sanguinis is absorbed; from the rete mucosum at the edge new cells are formed by budding, and thus the whole wounded surface becomes covered with epithelium and converted into a scar, which gradually shrinks and diminishes in vascularity. This process takes place in healing by first intention, in healing by scabbing, and in some instances in open wounds under aseptic treatment.

In *healing by first intention* the edges of the wound are brought into accurate apposition, and the deeper parts are thus protected from further irritation. Organisation of the lymph rapidly occurs, and the epithelium spreads over the surface in two or three days.

In *healing by scabbing* the edges are not brought into contact, but the superficial layer of the lymph dries up and forms a crust, which protects the deeper parts from external irritation; organisation of the lymph at the deeper parts occurs, and epithelium spreads over the wound beneath the crust.

In some cases in open wounds treated aseptically the antiseptic dressing takes the place of the crust. The process described above often occurs to a considerable extent around the margin of the wound, but the irritation of the antiseptic and the dressing is generally sufficient, when the wound is of considerable size, to keep up a slight amount of irritation and lead to the formation of granulation tissue in the centre of the

wound, and sometimes even to slight suppuration. It is important to remember that in all cases the primary inflammation only affects a microscopical layer, and the cutaneous margins of the wound remain quite pale.

When the wound is left open and exposed to irritation from without, the primary inflammation continues and leads to further changes, ultimately resulting in the formation of granulation tissue. Taking up the process at the point where it ceased in the former case, we no longer find the chief changes in the circulation but in the tissues. The migration of corpuscles goes on; the intercellular substance becomes soaked with serum, softened, and very soon absorbed: probably the connective tissue cells in the part proliferate, and ultimately we find nothing but a mass of embryonic cells in part composed of and derived from the migrated leucocytes, and probably in part also derived from proliferation of the tissue cells. In this embryonic tissue young capillary vessels are soon formed, and at the surface the new material grows out in the form of buds or granulations; hence the term 'granulation tissue,' applied to all inflammatory material having this structure. From the surface of the granulations suppuration now occurs, while the granulations grow and gradually fill up the wound till they reach the level of the surrounding skin. At the deeper part, however, the granulation tissue does not remain in the embryonic state, but being protected from irritation by the superficial layer, the further progress of the inflammation ceases, and organisation into fibrous tissue commences. The cells become elongated and form fibrous tissue; the walls of the blood-vessels become thickened from the formation of spindle-shaped cells around them; many of the vessels become obliterated, and the newly-formed fibrous tissue contracts, and the size of the wound is in this way reduced. When the granulations have reached the level of the skin the epithelium spreads from the margin, and as soon as the surface layer of granulation tissue is by that means protected from irritation, the changes just described as regards the deeper layer take place up to the surface. This

process is termed *healing by granulation*. It may be quickened if, after granulation is complete, the two sides of the wound are brought into close contact. In this case the two layers of granulations protect each other from external irritation, they adhere, and organisation rapidly takes place while epithelium spreads over the line of union. This process is called *healing by union of granulations*, or healing by the third intention.

There is another method of healing only seen in the case of wounds where aseptic treatment is thoroughly carried out, or in some rare instances where a crust forms; I mean *healing by organisation of blood-clot*. In order to explain this I must refer to what happens to blood-clots and dead portions of tissue enclosed in the body without access of air and dust. One of the most interesting and thorough investigations on this subject has been made by Dr. H. Tillmanns of Leipzig.[1] Tillmanns took portions of the liver, kidney, spleen, and lungs of rabbits, and hardened them in absolute alcohol for one to three weeks or longer. Pieces of these hardened dead tissues were then introduced with aseptic precautions into the peritoneal cavity of rabbits (in each case several pieces were used); after some days the animals were killed and the state of matters investigated. Twenty animals were experimented on, and into their peritoneal cavities about 100 portions of tissue were introduced. The animals did not appear the worse for the operation; the temperature remained normal, and they seemed well. Of these twenty animals only two died, both of acute peritonitis: in one case an error was committed in the treatment, the stitches were removed too early, and the intestines protruded: in the other case the animal was suffering before the operation from chronic peritonitis which afterwards became acute. When the animals were killed early, in a day or two after the operation, the masses of tissue were found to be adherent to some part of the peritoneum, and sometimes two pieces of tissue were

[1] 'Experimentelle und anatomische Untersuchungen über Wunden der Leber und Niere: ein Beitrag zur Lehre von der antiseptischen Wundheilung,' Virchow's *Archiv*, Bd. 78, 1879.

attached to one another. Where fourteen days or more were allowed to elapse, the portions of tissue were found firmly adherent and much diminished in size, evidently undergoing absorption; in some places there was only a thick layer of new material containing a pulpy mass in its interior. In one animal into whose abdominal cavity a whole kidney had been introduced, and which was allowed to live for forty-seven days, the kidney had entirely disappeared; the only thing noticeable was that at one part of the omentum there was a thickish tough spot, where probably the absorbed kidney had been attached. On investigating the process microscopically the following were briefly the appearances found: After twenty-four hours the mass of tissue is, as I have just said, adherent to the peritoneum and surrounded by a layer of soft new material—lymph. Any defects which existed in the margin of the specimen are filled up with this soft mass. This new material when examined is found to be composed of countless numbers of cells, which Tillmanns holds to be white blood corpuscles. If two pieces of dead tissue lie close to each other, they become adherent to each other by means of this material. If these tissues are examined at a later period, say forty-eight or seventy-two hours after their introduction, the cells are found to have increased in number and to be no longer confined to the outside of the organ, but to have penetrated into it where possible, forming, as Tillmanns puts it, streets and pathways of cells through the tissue. Thus, for example, in the case of the liver these cells penetrate in the first instance along the streaks of connective tissue which lie between the lobules, entering first those channels which are largest, but gradually spreading along the smaller ones. At this time the cells have already begun to develop to higher tissue, and not merely round cells, but also elongated spindle-shaped cells undergoing further development, are found. This process gradually goes on, the young cells penetrate more and more among the dead materials, which soon disappear by absorption, their place being taken by this young tissue which has come from without. This tissue rapidly undergoes

further development into fibrous tissue, vessels, &c., according to the well-known processes. The contraction of this young connective tissue and the further changes which it undergoes lead to the disappearance of the original mass and the formation of a cicatrix at its site, which also, as time goes on, tends to dwindle and disappear.

Where a portion of tissue covered by skin dies as the result of an injury, as after embolism, it gradually disappears by absorption, and its place is taken by newly-formed fibrous tissue. The process of absorption of blood-clots when subcutaneous is also essentially the same as that described in the experiments just mentioned. The blood-clot becomes infiltrated with young cells which develop into fibrous tissue, the original blood-clot becoming absorbed, and ultimately also much of the newly-formed material. The essential thing for the due absorption of blood-clots and sloughs is that they must be unirritating. Now the chief irritating causes are mechanical and chemical, and of these by far the most important are the chemical. A blood-clot may become chemically irritating by the addition of some irritating chemical substances from without, or by undergoing fermentative changes. When a blood-clot is subcutaneous, the skin protects it from saturation with chemical substances from without, and also in by far the greater number of cases from decomposition; for, as we shall see shortly, fermentations in organic fluids are always due to the growth of minute vegetable bodies in them, these bodies coming from the air and dust. Of the chemical causes fermentation is much the most important. The object of aseptic treatment is to exclude the causes of fermentation, and where this object is successfully attained the blood-clot, at any rate in its deeper parts, remains unirritating. In an open wound not treated aseptically the blood-clot generally putrefies, and, as a result, breaks down, liquefies, and is washed away with the discharge; the surface of the wound granulates and thus healing occurs. Where, however, the clot remains aseptic, and where it is protected from other sources of irritation, such as the action of the

antiseptic employed, the blood-clot undergoes the same changes as beneath the unbroken skin. It does not break down but remains, the wound being thus filled up with a solid brownish mass. After some days, if this clot is scratched, it bleeds, showing that new vessels have been formed in it. Also on lifting up the edge of the clot a broad margin of epithelium will be found. If the clot is left undisturbed, it frequently happens that after a time a superficial layer of tough brownish material (old blood-clot) may be peeled off and a complete scar found beneath. In some cases, however, organisation occurs in the clot up to the level of the skin, and cicatrisation spreads for some distance under the superficial unorganised layer, and then by-and-by the remaining central portion granulates, and we have a small superficial granulating sore which rapidly heals. If there is much movement of the wound, or if no prepared oiled silk (protective) be placed beneath the carbolic gauze, this organisation may be only imperfectly observed.

The process essentially consists in this: young cells (whether white blood corpuscles or derived from the connective tissue, or both, is not yet determined) pass into the blood-clot and develop into fibrous tissue and also vessels, which become connected with already existing ones, according to the various well-known methods of vascular formation. This process gradually extends to the surface till, after some days, as I have said, the blood-clot bleeds when scratched. When organisation has sufficiently advanced, the epidermis spreads from the edge. The original blood-clot takes no active part whatever in this process: it forms a mould in which the young cells develop, and is either used up as pabulum for these cells, or gradually removed by absorption. Here, just as when subcutaneous, the original blood-clot disappears, and its place is taken by young tissue which developed *in* it, not *from* it.

The objects of wound treatment are to get the most rapid and favourable healing of the wound with the avoidance of the various dangers and inconveniences incident to it. The ideal result is seen in the repair of subcutaneous injuries. One of

the best examples of the course of subcutaneous injuries is the repair of simple fractures in healthy subjects. Here there is extensive laceration of the soft parts, fracture, and it may be splintering of the bone and the effusion of a large amount of blood. And yet, in spite of these extensive injuries, as soon as the bone has been immovably fixed in proper position, the pain ceases, the swelling due to the effused blood gradually subsides, there is no increased rapidity of pulse or elevation of temperature, or if the temperature does rise a little it is only transitory and slight; rapid organisation of the blood and lymph and formation of new bone and connective tissue takes place, while the patient, if strong and healthy, is subjected to no risk.

Quite different, however, is the result if the skin over the seat of fracture is broken and the injured parts communicate freely with the exterior. The difference is still more marked if the old method of treatment by the application of water-dressing or poultices is adopted. However accurately and firmly the fracture may be put up, the edges of the wound begin to swell in a few hours, the skin around becomes red and the part becomes painful; the blood-clot, filling up the wound in the first instance, undergoes putrefaction, liquefies and disappears, and the inflammation in the wound goes on to the formation of granulation tissue and the occurrence of suppuration. Portions of the lacerated tissues may die, and after a time come away as sloughs, while the ends of the bones also very commonly necrose. At the same time the pulse becomes rapid and the temperature high: the patient has traumatic or inflammatory fever; this fever lasts for three or four days, and then gradually subsides. It may be that after separation of the dead portions of tissue or bone the wound heals up and the patient is well. But this is by no means always the case: the patient is liable to a great variety of inconveniences and dangers, to which I shall shortly allude. The death of the bone may not be confined to the exposed portion, but the suppurative inflammation may extend up beneath the periosteum or in the

medulla, giving rise to acute suppurative periostitis or acute osteomyelitis, in either case leading to death of large portions of the bone and very greatly endangering the life of the patient at the time. Further, the separation of the dead bone may occur very slowly and imperfectly, while the continuance of suppuration may lead to the development of lardaceous degeneration of internal organs, to hectic fever and death from exhaustion. In other cases abscesses form around the wound from time to time, leading to very serious consequences. Again, gangrene may occur in the wound and spread with great rapidity, giving rise to the necessity for amputation of the limb high up in order to save the life of the patient—traumatic gangrene. Or the wound may become covered with greyish or black pultaceous masses, spreading over the skin and tissues with great rapidity, destroying them and accompanied by low febrile symptoms—phagedæna. Again, a dark redness with a well-defined margin may spread from the wound over the skin, accompanied by fever and sometimes by abscesses—erysipelas. If the wound be very large it may happen that on the second or third day the patient becomes collapsed and dies in a few hours, with symptoms indicating the absorption of an intense poison—septic intoxication; or soon after, it may be immediately following, the traumatic fever, severe febrile symptoms may supervene and continue for a considerable time, leading often to the death of the patient—septicæmia. Or this fever may be of an intermittent type, accompanied by rigors and the formation of abscesses in internal organs, and of pus in various joints—pyæmia.

Summing up, then, the evils following compound fracture, we have traumatic fever, inflammation, suppuration, waxy degeneration, hectic fever, formation of abscesses, sloughing, acute necrosis, traumatic gangrene, phagedæna, erysipelas, septic intoxication, septicæmia and pyæmia, all these occurring because there was a communication between the injured parts and the external air. Before we can pass on to the best means of preventing these evils, we must shortly consider

why it is that the division of the skin is followed by these results; in other words, what are the causes of these various dangers which follow wounds: and we shall see that they are almost entirely due to the growth of minute vegetable organisms in the discharges from the wound or in the tissues of the body, these organisms entering the wound from without.

CHAPTER II.

BACTERIA AND DISEASE.

General description of bacteria, their origin and life history—Causes of septic intoxication—Inflammation and suppuration—Acute osteomyelitis—Erysipelas—Gangrene—Pyæmia—Septicæmia.

I MUST in the first place give a short description of the characters and life history of these minute organisms, before proceeding to the consideration of the part they play in the production of the diseases alluded to at the end of the last chapter. They

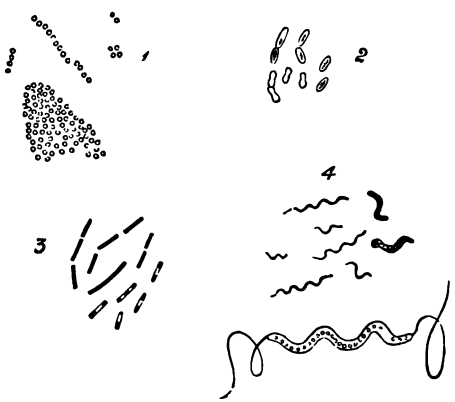


FIG. 1.—Common forms of bacteria.
1. Micrococci. 2. Bacteria. 3. Bacilli. 4. Spirilla.

are extremely minute masses of protoplasm of various shapes, and apparently in most cases structureless. They are divided according to differences in shape into four classes (see fig. 1): (1) micrococci, or round bodies; (2) bacteria, small oval rod-

shaped bodies, about twice as long as broad; (3) bacilli, rods of various lengths; and (4) spirochætæ, or spiral filaments. Some of them have a cilium at one or both ends, by means of which they can move actively in fluids; in some, however, in which movement is marked, the cilium has not yet been demonstrated. Others are always motionless, while many are for a time motile and afterwards become stationary. Often after they have become stationary they grow in masses, the individual members being joined to one another by a glue-like material of greater or less tenacity. This is termed the zooglœa stage, and the masses of bacteria are called zooglœa. Motion seems to be greatly favoured in most instances by the presence of oxygen, and is best seen at the edge of a drop of fluid containing the organisms.

The mode of growth is in all cases by division, though in some there is also a formation of spores. In the case of rods, division always occurs transversely to the long axis, but the micrococci may divide not only transversely to the long axis of a chain of cocci but also longitudinally, giving rise to the formation of triplets, fours in pairs side by side, &c. The new cells formed in this way may separate or may remain attached to each other, forming chains, or in the case of the micrococci small zooglœa masses. They grow very rapidly, the rapidity being dependent to a large extent on the nature of the soil and the temperature and moisture to which they are exposed. The common estimate is that they double their numbers once or twice in an hour.

Spore formation has only been worked out in the case of the bacilli. At one or more points in a rod a clear brightly refracting oval body appears, at first ill defined but later becoming sharp and well marked. At the same time the protoplasm of the rod gradually disappears till at length the spores are liberated. Spore formation seems to occur when the food of the plants is nearly exhausted, and it provides for the future existence of the organism. These spores are very resistant to heat and chemical agencies; they retain their vitality for years,

and when placed under suitable conditions they sprout and grow into the adult organism.

Though formerly it was supposed that these bodies might arise spontaneously in organic fluids, as the result of physical causes such as heat and electricity, it has been conclusively shown that the experiments on which these views were founded were erroneous, and at the present time there is no experimental fact known in favour of the view of spontaneous generation. It is now perfectly easy to keep any organic material quite pure for an indefinite time, if the vessel in which it is placed has been sterilised at a high temperature after plugging its neck with cotton wool, and if the material, after careful introduction into the vessel so as to avoid soiling of the neck, is heated to a temperature even considerably below the boiling-point of water for less than an hour every day for several days in succession.

It is much more difficult, but still possible, to preserve the fluids and tissues of the healthy living body without subjecting them to heat, the chances of contamination in transferring the organs to purified flasks being very great. Nevertheless, it has been amply proved that the thing can be done, and in this way it has been shown that the fluids and tissues of the healthy living body are free from micro-organisms.

Micro-organisms are present in large numbers in all dust, in water, on the surface of our bodies, and in the air in various localities. The introduction into a sterilised organic fluid of a minute object which has not been subjected to heat, or to the action of chemical agencies, will almost certainly be followed by the development of micro-organisms, because they are present on all surrounding objects. This is a point of the greatest importance in the treatment of wounds.

These micro-organisms grow on various soils, though some are more particular than others. The substances essential for their nourishment are water, phosphates, salts of potash, carbonaceous and nitrogenous organic substances. An important point is the reaction of the medium, neutral or slightly alkaline

substances being best for most bacteria. Most forms require free oxygen or grow much more rapidly in it, but there are some which will not live unless oxygen is almost or entirely absent. As the result of their vital action these bodies produce extensive alterations in the materials in which they grow. They break up the complex organic compounds and reduce them to simpler forms. In this way they cause fermentation and decomposition of organic substances. In some instances well-known chemical substances are thus formed, and the agency of the micro-organisms is extensively employed in the manufacture of various articles of food and drink. In other cases, however, the substances which they produce are extremely poisonous, and when injected into animals cause symptoms of poisoning resembling the effect of various alkaloids. There is one class of organisms which gives evidence to the naked eye of the changes they occasion in the materials in which they grow; I refer to the pigment-producing organisms. The spot on which these organisms are growing assumes a definite colour when it is exposed to the air. These colours are very numerous, red, yellow, green, blue, &c., and the same colours are always produced by the same organism when it grows on a suitable soil.

Some micro-organisms can grow in the animal body, giving rise to a variety of diseases. Some are fatal to most animals; for example, the bacillus of anthrax: others again are only pathogenic in certain species of animals. The diseases caused by the growth of these bodies in the blood and tissues are grouped together under the term 'infective diseases.' Of these there are two kinds, those in which the infection occurs from a wound or open surface—traumatic infective diseases—and those in which no wound is necessary, and where the pathogenic organisms are supposed to be able to enter the body through uninjured surfaces. It is with the former that we have here to do.

I have already mentioned that some micro-organisms produce such alterations in organic fluids that the injection of these fluids into animals is followed by symptoms of poisoning,

and if in sufficient quantity by fatal results. These symptoms set in during or soon after the injection (from a quarter of an hour to two hours). Where a quantity insufficient to cause death is injected, the temperature becomes elevated two or three degrees or more, and this fever lasts for a few hours. Where the quantity used is larger there may be preliminary rise of temperature, but if death is about to occur it falls below the normal, accompanied by collapse and sometimes by diarrhœa and vomiting. Panum, who first worked at this subject, showed that the symptoms were due to a chemical substance and not to multiplication of bacteria in the body. He boiled these poisonous putrid fluids for eleven hours and then injected them into animals, and he found that they were still poisonous, though not quite so powerful as before being boiled. He also filtered the fluid, boiled it for an hour, evaporated to dryness, digested it with absolute alcohol, and then treated the residue with boiled water, this watery extract being also very poisonous. Bergmann states that he has been able to extract the poison in the form of a crystalline substance, to which he has given the name 'sepsin.' From these experiments it is evident that there is present in putrid fluids a chemical substance produced by bacteria, which, introduced into the circulation of an animal, acts as a poison, like strychnia or any other alkaloid. In small quantities this substance causes febrile symptoms which, however, soon pass off unless the dose is repeated, while in larger amount it causes death more or less rapidly. The clinical evidence shows that this material is also poisonous to man. Where a wound is quite small, or where it has been treated antiseptically, in other words where the poison is in small amount or entirely absent, there is no fever or other symptom of poisoning. Where the wound is larger and antiseptic treatment is not adopted, and where the wound does not heal by first intention, this material is absorbed and gives rise, for a few days, to fever—traumatic fever. Again, when there is a very large raw surface in contact with putrid discharge, as in a hip-joint amputation, a large quantity can be rapidly absorbed and produce fatal effects.

Or, again, when the patient is weakly and when his excretory organs act imperfectly, as in renal disease, a comparatively small dose may cause a fatal issue. Hence the danger of operating in cases of Bright's disease, a danger much diminished where aseptic treatment is adopted. These symptoms are now grouped under the title of 'septic intoxication.' That they are really due to absorption from the wound is further shown by the fact that as soon as granulation has occurred the symptoms subside, even although the discharge from the wound be considerable in amount and intensely putrid.

While the products of the growth of certain bacteria give rise to general effects—traumatic fever and septic intoxication—they also act locally on the wound and cause inflammation and suppuration. The occurrence of inflammation and suppuration in a wound is probably due to various causes, but the chief causes are the growth of micro-organisms in the discharges from the wound or in the tissues giving rise to the formation of irritating substances. In the case of a wound it is not necessary to suppose that there is only one form of micro-organism which will cause it to inflame and suppurate. Many irritating substances if applied to a cut surface will cause inflammation and suppuration, such as croton oil, tartar emetic, &c., and in the same way many of the products of the fermentation of the discharges are sufficiently irritating to cause inflammation and suppuration of the cut surface. For it must be remembered, as pointed out in the first chapter, that the superficial layer of a cut surface is for a short time in a state of inflammation as the result of the injury done to the tissues by the knife, and very slight irritation applied to this inflamed surface will suffice to keep up the inflammation, lead to the formation of granulation tissue and the occurrence of suppuration. In treatment with various antiseptics it often happens that the direct application of the antiseptic to the wound, especially when it is in strong solution, irritates the wound and leads to suppuration. The recognition of this fact led Sir Joseph Lister to interpose between the wound and the

dressing a layer of prepared oiled silk, with the view of keeping the antiseptic from the wound. Again, if from imperfect drainage the discharge becomes pent up, inflammation is caused, and if the tension is not relieved it may end in suppuration. The effect of tension is of course greatly increased if, at the same time, micro-organisms develop in the retained fluids. Again, inflammation and suppuration may be caused not merely by growth of micro-organisms in the discharges of the wound, but also by growth of micro-organisms in the tissues themselves. This effect is only caused by certain micro-organisms, for, on the one hand, many micro-organisms will not grow in the living blood or tissues, but yet growing in the discharges can produce irritating materials and cause suppuration; while, on the other hand, many micro-organisms grow in the living tissues without causing suppuration. The micro-organisms which grow in the living tissues and cause suppuration belong, so far as is known, almost entirely to the group of micrococci. They grow in the walls of the wound, and give rise to irritating products which keep up the inflammation and suppuration. They often cause extension of the inflammatory process, or burrowing of the pus, as it is termed, and sometimes spreading into the neighbouring tissues they give rise to the formation of abscesses. This will be presently alluded to, and the relation of micrococci to suppuration will be discussed more fully. In the meantime I may sum up the causes of inflammation and suppuration in a wound as follows: 1. Decomposition of the discharge from the wound. 2. Application of irritating chemical substances to the wound, amongst others various antiseptics. 3. Tension from accumulation of discharge, more especially when the retained discharges undergo fermentation. 4. Growth of micro-organisms in the tissues at the surface of the wound.

I have just stated that when micrococci grow in the walls of wounds they may spread into the tissues, and there set up an acute abscess. When the pus of an acute abscess is examined, micrococci are always found in it, sometimes in large

numbers, sometimes only few. The relation of the micrococci to the acute inflammatory process has been much debated, and in the 'British Medical Journal' for September and October 1884 will be found a full discussion of the subject. The facts seem to be the following. The micrococci associated with inflammation are of several kinds. Some forms can cause inflammation, just as anthrax bacilli cause anthrax,

FIG. 2.

Section of kidney, showing plug of micrococci surrounded by a clear necrotic layer, and outside this a ring of inflammatory tissue. The poisonous material produced by the micrococci when strong kills the tissue, when more dilute sets up inflammation.

&c.: there need be no previous injury or disease of the part. Direct evidence can be obtained with regard to some micrococci, that their injection into animals is always followed by the formation of abscesses. In Koch's 'Traumatic Infective Diseases,' translated by the Sydenham Society in 1880, an account

will be found of a spreading abscess formation in rabbits, where masses of micrococci were always seen preceding the inflammation, the injection of a minute quantity of these micrococci being always followed by the same progressive suppuration. There seem to be other forms which can cause abscess only if the part has been previously injured or inflamed. Thus in

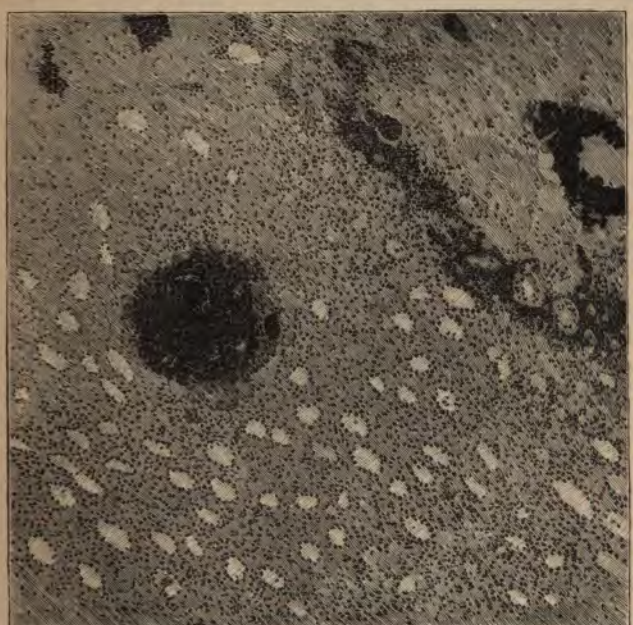


FIG. 3.

Section of kidney, showing in the upper corner a mass of micrococci, a clear necrotic ring and a layer of inflammation, as in fig. 2. In the centre is the further stage of the process: the inflammatory cells and the micrococci have now infiltrated the necrotic ring, and an abscess is the result. (For further details as to figs. 2 and 3 see 'Brit. Med. Journal' for Sept. and Oct. 1884.)

abscess in the mamma during the early period of lactation the primary lesion is probably an inflammation resulting from an injury, cold, &c.; the micrococci then settle in the part, grow, and cause suppuration.

Quite recently[1] Becker and Krause have worked out the micrococcus associated with acute osteomyelitis in man. They have found a micrococcus constantly present in this disease which forms orange-yellow colonies when grown on gelatinised meat infusion or on potatoes. The injection of this organism into the veins of rabbits did not produce any disease of the bones unless these were previously injured; but if the bones had been bruised or broken, the organisms set up abscess under the periosteum, suppuration between the ends of the bone, and suppuration sometimes in isolated spots in the medullary tissue, a result corresponding to the disease in man. We have thus direct proof that acute necrosis of bone is due to micrococci, and there is evidence to show that the abscesses occurring in the neighbourhood of wounds are likewise due to similar though not necessarily to the same organisms.

Among the most marked results of the growth of micro-organisms in the tissues is erysipelas. If portions of the spreading margin of the redness and of the healthy skin in the immediate vicinity be excised and cut into sections, it will be found that in the healthy skin immediately beyond the red margin the lymphatic vessels contain large numbers of a minute micrococcus frequently arranged in chains (see fig. 4). At the red margin itself there are inflammatory appearances as well: the lymph vessels contain not only micrococci but also numerous leucocytes, and there is a small-celled infiltration around them and in the skin. The micrococci also extend into the lymph spaces and canals of the skin. Fehleisen, who has worked out the subject,[2] has succeeded in cultivating these organisms on gelatinised meat infusion, solidified blood serum, &c. After disinfecting the skin at the spreading margin of redness, he cut out little bits and embedded them in the cultivating material. Minute colonies of micrococci grew, and continued growing for about six days, when they were reinoculated into fresh tubes.

[1] *Deutsche Medicinische Wochenschrift*, 1883, and *Fortschritte der Medicin*, 1884.

[2] *Die Ætiologie des Erysipels*, 1883.

Having in this way obtained a pure cultivation, he inoculated rabbits at the tip of the ear. In thirty-six to forty-eight hours the redness and swelling began, and spread from the tip over the ear and thence over the body. Sections through the spreading margin showed the same appearances as the sections of the skin in man: micrococci were present in the lymphatic vessels. Excision of the whole ear before the redness had reached the base arrested the process. He further inoculated man with the cultivated micrococci, and produced erysipelas in that way. It has been observed that lupus, rodent ulcer and various malignant diseases often disappear or improve very much after an attack of erysipelas, and it has been proposed,

FIG. 4.

Section of skin at the spreading margin of the redness in erysipelas (from a photograph by Koch, x. 700). A lymphatic vessel is seen containing micrococci, which are also spreading into the tissues around.

and indeed carried out in some cases, that, where operation is not possible, erysipelas should be induced by the inoculation of pus from a wound affected by erysipelas. Fehleisen treated a number (7) of these cases with inoculation of the cultivation of micrococci instead of pus, and produced typical erysipelas by this means. He also found that a patient was protected for a short time—but only for a short time—from a fresh attack of erysipelas.

In Koch's 'Traumatic Infective Diseases' another very

interesting set of experiments are described on the production of spreading gangrene in mice. At the spreading margin of the gangrene, and preceding the gangrene, he found large numbers of streptococci in the tissues. The inoculation of these streptococci on other mice was followed by the development of the same gangrenous process. Phagedæna and spreading traumatic gangrene in man are in all probability in like manner due to the rapid spread of organisms in the tissues. Indeed, micro-organisms have been found in these cases, but the relationship has not as yet been thoroughly worked out. All the facts point to a similar mode of origin to that of spreading gangrene in mice, a view much confirmed by the absence of these diseases where antiseptic methods of treatment are employed. I do not, of course, ascribe all cases of gangrene to the spread of micro-organisms in the tissues; I refer merely to acute spreading gangrene and phagedæna. Gangrene may occur as the result of destruction of the tissues at the time of the injury, or it may occur in enfeebled tissues after an operation, as, for example, in stumps after amputation for senile gangrene, or for the result of frost-bite. In this case the tissues are so weak that they are unable to withstand the inflammation which occurs in the wound. This inflammation is, however, caused either by growth of micro-organisms in the discharges or tissues of the wound, or by tension. If this pathology is correct, it follows that it is safe to operate early in cases of senile gangrene and gangrene after cold, provided that micro-organisms are excluded from the wound, and that the drainage is satisfactory. Experience with the aseptic method of treatment shows that this is correct. I may thus sum up the pathology of gangrene after operations or injuries: 1. It may result from direct destruction of the tissue at the time of the injury, from injury to large blood-vessels, &c. 2. It may occur as the result of inflammation in a weak part. In this case the inflammation is set up by the growth of micro-organisms in the discharge or tissues of the wound, or by tension in the wound. 3. It occurs as the result of growth of bacteria in the tissues in

a way corresponding to gangrene in mice, seen in phagedæna and traumatic gangrene.

Pyæmia in rabbits has been shown to be due to the growth of micrococci in the blood.[1] These micrococci are very minute; they grow in colonies and tend to adhere to the red blood corpuscles. Masses are thus formed composed of colonies of micrococci with included red blood corpuscles. These masses may adhere to the wall of a blood-vessel, grow and block it completely, or being swept on in the circulation form emboli in the smaller vessels. In either case inflammation occurs around, and an abscess is formed in which are found numerous micrococci: the inoculation on another animal of the pus from these abscesses, or of the blood containing the micrococci, is followed by the reproduction of the disease. In man the subject has not been thoroughly worked out; but micrococci have been found in the blood and in the secondary abscesses, and plugs of micrococci are often found in internal organs. All the facts point to this pathology of the disease; indeed, it is the only view on which all the appearances can be explained.

Septicæmia is a much more complicated affection, and probably arises under several circumstances. Continued absorption of the poisonous material from wounds referred to under the head of septic intoxication will keep up a feverish state with all the symptoms of septicæmia, and if long continued may terminate fatally. In other cases the micrococci grow in the tissues of the wound, and pour their products or ptomaines, as they are called, into the blood. Here micrococci may be found in the blood, but the essential seat of disease is the tissues. In a third form micrococci grow in the blood, and multiplying there give rise to the symptoms. In a fourth form organisms grow in the blood; but they belong to the class of bacilli. The last two cases correspond to what is found in the lower animals (mice, rabbits, &c.). In them septicæmia is caused by more than one form of organism growing in the blood, and giving rise

[1] See Koch's *Traumatic Infective Diseases.*

to symptoms and post-mortem appearances which can only be classed together as septicæmia. In mice, the most common form is a minute bacillus found in enormous numbers in the blood. These bacilli may be cultivated on gelatinised meat infusion, and their reinoculation on mice produces the same disease. A small bacterium and other micro-organisms also kill mice in the same manner.

CHAPTER III.

DESTRUCTION OF BACTERIA.

Experiments on disinfectants, carbolic acid, bichloride of mercury, &c. —Principles of wound treatment—Aseptic and antiseptic surgery.

NUMEROUS researches have been published on the subject of the destruction of micro-organisms by various antiseptic or disinfectant substances. With few exceptions these are open to grave objections, and in what follows I shall therefore only refer to the most recent and accurate research by Dr. Koch.[1] The former experiments were chiefly made by adding varying proportions of the antiseptic substances to cultivating fluids containing a variety of forms of bacteria, or by treating a mixture of bacteria with various antiseptics of different strengths, and afterwards testing the power of growth in cultivating fluids. In this method no account was taken of possible differences in the resisting power of different bacteria, and the great resisting power of the spores was more especially left unnoticed. In Koch's researches pure cultivations of different organisms were employed, and special attention was paid to the presence of spores. The experiments were also carried out on a solid cultivating material, and thus there was less risk of error from the accidental development of micro-organisms coming from the air. I may refer in detail to the experiments on carbolic acid.

In the first place, the power of carbolic acid in destroying spores and also non-spore-bearing organisms was tested. For the former experiment bacillus anthracis containing spores was employed; for the latter micrococcus prodigiosus and the bacteria of blue pus were used. The difference in resisting power

[1] *Mittheilungen aus dem k. Gesundheitsamte*, vol. i. Berlin 1881.

between bacillus anthracis containing spores and the adult form of the organism without spores was also tested. The spore-bearing bacilli, the micrococci, and the bacteria of blue pus were obtained by soaking sterilised cotton or silk threads in cultivations of these organisms and drying them rapidly. The spores retain their vitality in the dry state indefinitely, the micrococci and bacteria only for a few days; the latter were therefore always freshly prepared before the experiment. The non-spore-bearing bacilli were obtained by rubbing up the spleen of an animal just dead of anthrax with the sterilised threads. In the spleen the bacilli do not contain spores if taken immediately after the death of the animal.

In the first instance, the resistance of spores to watery solutions of carbolic acid was tested. A vessel was filled with watery solutions of carbolic acid of various strengths, and the spore-bearing threads were left in this fluid for a certain time; they were then taken out, in some cases washed with boiled distilled water, and placed on the solid cultivating materials. As a result, it was found that the spores of the bacillus were unaffected after being in a 2 per cent. solution and under for two days; they developed more slowly if left for two days in a 3 per cent. solution; in a 4 per cent. solution after one day their growth was slower; and in a 5 per cent. solution after one day only one or two grew. On the other hand, bacilli of anthrax which did not contain spores were killed by immersion for two minutes in a 1 per cent. solution of carbolic acid. Micrococci and other organisms not containing spores are similarly destroyed with great rapidity by watery solutions of carbolic acid.

It was also necessary to learn what proportion of a disinfectant must be mixed with a fluid in order to hinder bacteria from developing, although their vitality may not be destroyed. It was found that in meat infusion containing pepton $\frac{1}{850}$th to $\frac{1}{1250}$th part of carbolic acid was sufficient to prevent the growth of bacillus anthracis.

The vapour of carbolic acid at the ordinary temperature did

not destroy the spores of the ordinary bacilli found in earth, although allowed to act as long as forty-five days. If, however, the vapour acted at a temperature of 75° C., spores in earth were destroyed in from two to three hours, and even after exposure for an hour and a half to the vapour at 55° C. only a few colonies developed, showing that spores are destroyed in that time, but that some were protected more than others, and hence not so rapidly affected.

A 5 per cent. solution of carbolic acid in oil did not affect spores of bacillus anthracis, although they were left in it one hundred and ten days, and the non-spore-bearing bacilli were not completely destroyed till after six days, though on the third day some had apparently been killed. A 5 per cent. solution in alcohol was also employed without effect on the spores.

The carbolates were much less potent than pure carbolic acid. Next in power to carbolic acid was the sulpho-carbolate of zinc, which interfered with the luxuriance of the vegetation of the spores in one day, and completely destroyed them in five days.

Before going further I shall consider how these results affect the question of carbolic acid as an antiseptic in the treatment of wounds. When it was first introduced nothing was known of the existence of resisting spores, and it was thought that a strong solution (5 per cent.) of carbolic acid killed micro-organisms almost instantly. The results mentioned above, however, show that while micrococci and other organisms without resistant spores are killed in a few seconds, spores can retain their vitality for a considerable time. The experiments do not show the precise time at which spores are destroyed, for, though in one experiment development occurred at one part of the thread after soaking for twenty-four hours, this fact does not imply that the spores withstood a 5 per cent. watery solution of carbolic acid for that time, but only that some of them were imperfectly acted on. There is no evidence of the existence of different resisting power of the spores of the same organism, and therefore we have to find the earliest time in which they are killed. This has not yet been worked out, but evidently it is considerable.

In the Listerian method of treatment, then, the methods of disinfecting hands, instruments, &c., are sufficient to destroy everything but the resisting spores of some bacilli. But as I have pointed out at some length elsewhere,[1] after an operation performed aseptically the discharge will be found to contain no organisms, or if any are present, they belong to the class of micrococci. They enter by developing in the discharge beneath the dressing when the latter is left on for several days, or when the discharge is profuse. Why, if the spores of bacilli are not killed by the solution of carbolic acid, are they not found in the discharge from the wound? Either they do not gain access to the wound, or if they get in, the circumstances under which they are placed are unfavourable to their growth. It is probable that on the skin there are but few spores, for the heat and moisture will rapidly cause them to germinate, when they will be readily destroyed by the carbolic acid lotion. The spores in the air and on the instruments will, if they fall into the wound, fall into a fluid containing carbolic acid from the spray, a fluid in which they will be incapable of germinating, while in a very short time they will be destroyed by the action of the living tissues; for, as will be seen in referring to my 'Antiseptic Surgery,' the living tissues can destroy organisms. In all probability but very few spores fall into a wound, for even where tension occurs early in cases treated aseptically, I have never found bacilli in the retained fluid. The carbolic spray, though practically in my experience of the greatest value, has since the publication of Koch's research, been regarded as of little use. The above remarks show that it may be of the greatest service, not merely in destroying non-spore-bearing organisms and in keeping the hands, instruments, and skin pure, but also in adding carbolic acid to the fluids of the wound, and thus preventing the development of spores.

Carbolic oil is also found in practice to act very well as an antiseptic, but from the fact mentioned above, it does not destroy spores, and only acts very slowly on the mature organism.

[1] *Pathological Transactions*, 1879, and *Antiseptic Surgery*, 1882.

The difference between the experimental and the practical results is probably owing to solution of the acid from the oil in the fluids of the wound, thus giving rise to a watery solution.

Sulphurous acid is another disinfectant which has been much used, but which is apparently not so effectual as has been supposed. Dry micrococci are killed by a 1 per cent. per volume vapour in twenty minutes, if moist, in two minutes. Spores of anthrax, earth and hay bacilli exposed for ninety-six hours to a vapour of sulphurous acid, at first of the strength of 6·1% volume per cent., and after ninety-six hours of the strength of 3·3 per cent., were quite unaffected.

In solution sulphurous acid was somewhat more powerful. A saturated solution of the gas in water was obtained, and this was diluted so that four strengths were tested.

The 1st vessel contained	11·436	p.c. by weight	(4,000	vol.	p.c.)
„ 2nd „ „	5·718	„ „	(2,000	„	„)
„ 3rd „ „	2·859	„ „	(1,000	„	„)
„ 4th „ „	·286	„ „	(100	„	„)

In each of these vessels were placed several threads containing anthrax spores, and some of the threads were taken out at various times and the power of development of the spores tested. In the first vessel, after one day, development was somewhat delayed, and after more than one day did not occur at all. In the second vessel there was also delayed vegetation after one day, but none of the spores were killed till the third day. In the third vessel no delay in development till the third day, and apparently none were killed after five days. In the fourth no apparent effect after five days.

A 5 per cent. solution of chloride of zinc did not kill anthrax spores after a month's immersion, and chloride of zinc added to serum in the proportion of 5 per thousand did not hinder the development of these spores.

Of chemical substances able to destroy spores with great rapidity, bichloride of mercury is the most potent. Mixed with the cultivating material in the proportion of 1 to 300,000, the bacillus anthracis was unable to grow. Spores of anthrax dried

on threads and placed in a watery solution of 1 to 20,000 for ten minutes were destroyed. Solutions of 1 to 5,000 or stronger destroy all spores with certainty in a few minutes; indeed, to wet the spores with a spray of this solution and then allow them to dry is sufficient to destroy them.

Of the various other disinfectants employed, only the following were able to kill the spores of bacillus anthracis in less than twenty-four hours :—

Chlorine water.
Bromine water (1 p.c.).
Iodine water.
Permanganate of potash (5 p.c. in water).
Boracic acid (5 p.c. in water).

The following acted slowly and imperfectly on the vitality of the spores :—

Ether (incomplete[1] destruction after 8 days, complete after 30 days).
Aceton (incomplete after 5 days).
Iodine, 1 p.c. in alcohol (incomplete after 1 day).
Sulphuric acid, 1 p.c. in water (incomplete after 10 days).
Sulphate of copper, 5 p.c. in water (incomplete after 5 days).
Boracic acid, saturated watery solution (delayed vegetation after 6 days).
Hydrochloric acid, 2 p.c. in water (complete on the 10th day).
Arsenious acid, 1 per 1,000 in water (complete after 10 days).
Sulphide of ammonium (complete after 5 days).
Formic acid, 1·12 specific gravity (complete on the 4th day).
Quinine, 2 p.c. in water ($\frac{2}{5}$) and alcohol ($\frac{3}{5}$), (incomplete after 1 day).
Turpentine oil (incomplete on the 1st day, complete after 5 days).
Chloride of lime, 5 p.c. in water (incomplete on the 2nd day, complete on the 5th).
Perchloride of iron, 5 p.c. in water (delayed development on the 2nd day, complete destruction on the 6th).
Absolute alcohol (no effect on the spores after 110 days).
Glycerine (no effect after 110 days).
Chloroform (spores unaffected after 100 days).

[1] By incomplete is meant that only some spores grew, *i.e.* where the solution got free access to the spores it killed them, but where the action was imperfect they still retained vitality.

Benzoic acid, concentrated watery solution (spores unaffected after 70 days).

Thymol, 5 p.c. in alcohol (spores unaffected after 15 days).

These facts show that though the ordinary antiseptics are sufficient when the virus is a bacterium which is not spore-bearing, yet when spores have to be dealt with they are insufficient. In using antiseptics there is another point which must not be lost sight of. Thus, one antiseptic may form compounds with substances in the fluids and lose its properties, while another, which is in reality weaker, may not do so, and thus be more effectual. Thus, in recent experiments on the destruction of tubercle bacilli in phthisical sputum, Schill and Fischer[1] found that bichloride of mercury solution (1 to 500 in water), added to an equal quantity of sputum, failed to destroy the tubercle bacillus even after twenty-four hours' action, while a watery solution of carbolic acid (5 per cent.) added to sputum in the same proportions disinfected it thoroughly in twenty-four hours. And yet, acting on dry spores of Bacillus anthracis the bichloride solution is very much more rapid in its action than carbolic acid. In the case of sputum the result probably depends on the different chemical affinities of the two substances, the bichloride either losing its antiseptic properties by entering into new combinations, or being unable to penetrate and act on the masses of secretion which contain the bacilli.

Although not directly of use for surgical work, it may be interesting to refer shortly to the results obtained as regards disinfection by hot air and steam. Disinfection of masses such as bedding is not possible with hot air, because, while the outer layer may be raised to a temperature which chars it, the temperature of the interior may not be sufficiently high to destroy bacteria. I may mention one experiment to illustrate this. A piece of linen about forty inches long was rolled up tightly, thirty-two complete turns being made, in this way giving sixty-four layers from one side to the other. Maximum thermometers were placed in the middle of the roll and between every

[1] *Mittheilungen aus dem k. Gesundheitsamte*, vol. ii. Berlin, 1884.

fourth turn from within outwards. The whole was placed in a disinfecting oven and exposed to hot air. The experiment began at two o'clock P.M. and lasted for four hours. The temperature of the air in the interior of the oven was taken at different times, and was as follows :—

At 2 P.M.	227° F.
„ 2.20 „	284° „
„ 3 „	293° „
„ 4 „	298° „
„ 4.20 „	298° „
„ 5 „	302° „
„ 5.30 „	298° „
„ 6 „	298° „

When taken out at 6 P.M. the following were the readings of the maximum thermometers :—

In the middle of the roll	94° F.
4 turns from the middle	109° „
8 „ „ „ „	126° „
12 „ „ „ „	152° „
16 „ „ „ „	165° „
20 „ „ „ „	175° „
24 „ „ „ „	182° „
28 „ „ „ „	212° „

As a temperature of 280° F. to 300° F. is necessary for the destruction of bacteria when exposed to dry heat, it is evident that the proper disinfection even of small masses of clothing, &c., is impossible in a hot-air chamber.

Superheated steam has also been tested in the same manner with a similar result. The temperature in the interior of the mass did not rise sufficiently high to destroy bacteria. This was also practically tested in these experiments, by placing spores of bacilli and the much more easily killed micrococcus prodigiosus at various parts of the roll; they were afterwards sown on suitable cultivating material. In the case of the experiment mentioned above, these organisms were placed along with the seven deepest thermometers, and when sown afterwards all grew.

If, however, the steam is not at rest but constantly passes

over the material to be disinfected, the temperature rapidly rises and soon attains the same height in the interior of the roll that it has outside. At the same time a current of steam passing over spores effectually destroys them, acting in this way like boiling water. To disinfect bedding, clothes, &c., it is therefore evident that the best way is to expose them to a current of steam for about three hours. If the boiling-point of water is raised by adding salts, it is found that the temperature of the steam is also above 212° F. In some cases, especially where a more rapid effect is wanted, this would be an advantage.

We have now considered the modes in which wounds heal, the diseases which may follow wounds, the causes of these diseases, and the means by which these causes may be destroyed. We therefore come next to the application of this knowledge to the treatment of wounds. It is evident that all treatment must be directed against the causes of wound diseases, care being taken at the same time to permit the wound to heal. In other words, all treatment must be antiseptic. As we shall see immediately, there are various modes in which the principle may be carried out. The short meaning of the term 'antiseptic treatment' is treatment directed against the causes of putrefaction. But only some of the diseases to which we have already alluded are connected with putrid changes in organic matter. The micrococci of erysipelas, for example, do not produce any putrid change. All organisms, however, alter the composition of the materials in which they grow, that is, all cause fermentation of some kind or other. We must therefore somewhat expand the meaning of the term 'antiseptic treatment,' to include treatment directed against the causes not merely of the putrefactive fermentation, but of all fermentations. That it is sufficient to direct our attention to the matter of fermentation in wounds I have shown at length in my larger work on Antiseptic Surgery, to which I must refer the reader. It is there demonstrated that it is from particles falling into organic fluids or on tissues that micro-organisms develop; that it is only after the access of particles from the outer world

to such fluids and tissues that fermentations occur; that the particles which cause fermentations, and those which give rise to organisms, are one and the same—in other words, that fermentations are due to the growth of micro-organisms in the fermenting substances; that micro-organisms are not present in the fluids and tissues of the healthy living body; that, so long as an animal is healthy, dead tissues and fluids may remain in closed cavities in the living body without undergoing fermentation, and may even entirely disappear, but that as soon as atmospheric air with its dust is admitted, organisms develop and fermentations occur; and that it is very seldom that the organisms gain access through the circulation to dead tissues and fluids enclosed in the animal body. The relation of bacteria to disease I have just described. It is thus clear that precautions that are effective against the causes of fermentation will equally prevent the dangers due to bacteria.

There are two great principles on which we may carry out the antiseptic treatment of wounds. A.—We may aim at the complete exclusion of living organisms from wounds, thus preventing the possibility of their developing there. This is the principle on which the method of treatment introduced by Sir Joseph Lister is based, and may be termed for the sake of distinction the aseptic method. Various surgeons use different antiseptics and dressings, though still adhering to the principle of complete exclusion of living organisms. The principle is generally called the Listerian *principle* or Listerism, and the particular aseptic method on which this principle is carried out by Sir Joseph Lister, the Listerian *method*. It does not necessarily follow because a surgeon does not employ the method recommended by Sir Joseph Lister that therefore he is not practising Listerism. That depends on whether or not he acts on the principle of complete exclusion of living organisms, and whether his method fulfils that purpose.

B.—We may allow living organisms to enter wounds and then take means to impede their growth in the discharge and in the tissues. It is of course at once evident that this is a less certain plan, and that the result must depend to a great extent

on chance : once organisms enter a wound the result is no longer completely under our control.

The antiseptic methods which merely *interfere* with the development and fermentative action of organisms on the fluids and tissues in wounds, and which do not aim at their total exclusion, may act on various principles.

1. By the addition of various antiseptics to the discharge, either in the wound, or after it flows out, this discharge may be rendered an unfit soil for the development of organisms.—*Use of antiseptics.*

2. The discharge may be allowed to flow away so rapidly as not to have time to undergo fermentation to any extent in the wound itself.—*Free drainage.*

3. This removal of the discharge may be facilitated by washing it away constantly with water alone, or with water containing antiseptics.—*Treatment by irrigation or by water bath.*

4. By freely exposing the discharge to air evaporation takes place, and the fluid becomes too concentrated to permit the growth of bacteria, while, at the same time, by supplying these organisms with plenty of oxygen, they have no necessity to break up the albuminous compounds in their search for oxygen, and thus, as shown by Pasteur, their fermenting power is diminished.—*Open treatment.*

5. By keeping the parts at perfect rest and by operating only when the patient is in good health, the tissues and the blood are in such a state as to resist the development of bacteria in the thin layer of lymph between the cut surfaces, and union by first intention thus occurs. This is best carried out *by perfect rest and accurate apposition of the cut surfaces.*

Healing by scabbing acts on the last two principles.

Although these various methods may be described as acting on these different principles, yet there is no hard and fast line between one and the other. Indeed, at the present day advantage is now constantly gained from the use of the various principles combined—as, for instance, by the employment of free drainage, antiseptic irrigation, &c., in the open method.

CHAPTER IV.

ASEPTIC SURGERY—MATERIALS EMPLOYED.

Problems to be solved in order to keep a wound aseptic: Carbolic acid —*Carbolic lotions—Pure carbolic acid—Solution in methylated spirit —Carbolic oil—Carbolic acid and glycerine*: Spray producers: Catgut—Carbolised silk: Protective: Carbolic gauze—Macintosh: Sponges: Boracic acid—*Boracic lotion—Boracic lint—Boracic ointment*: Salicylic acid—*Salicylic acid cream—Salicylic ointment*: Chloride of zinc: Iodoform: Carbolised cotton wool.

Aseptic surgery is based on the principle first enunciated by Sir Joseph Lister, viz. the *exclusion* of active ferments from the discharges of wounds.

Theoretically, this is the ideal form of antiseptic surgery, for here, supposing that the attempt is successful, the causes of putrefaction do not enter the wound in a state capable of producing fermentation, and therefore decomposition of the discharges, or of dead portions of tissue, &c., cannot possibly occur.

The problem which Sir Joseph Lister sought to solve may be shortly stated as follows :—

On all objects in the external world septic dust is present—on the skin of the patient, on the hands of the surgeon and his assistants, on all instruments, in water, in the air, &c.; and when a wound is made any introduction of this dust must be carefully avoided. Then after the wound has been made, care must be taken to prevent its entrance during the after-treatment. Some sort of dressing must be provided which shall prevent its passage in an active state, and at each change

of this dressing the problem is the same as at the time of infliction of the wound. Such being the question at issue I must now proceed to the modes in which it has been answered.

I shall first enumerate the substances employed in aseptic surgery.

Carbolic Acid is the antiseptic employed to destroy the particles in the air and on surrounding objects which give rise to putrefaction. It is obtained in the solid state and of extreme purity from Bowdler and Bickerdike, Church, Lancashire, who give it the name of Absolute Phenol. It is used in various forms.

The *Carbolic lotions* used are of two strengths—1 in 20 and 1 in 40; one part of crystallised carbolic acid dissolved in 20 and 40 parts of water respectively. The solution is kept in a stoppered bottle in order to avoid evaporation of the acid. It ought to be quite clear; when it is not so, and more especially when globules of oily matter are present, it is impure, the oily particles consisting of cresylic acid. It is a mistake to add alcohol or glycerine to aid the solubility of the acid, because these substances hold the acid more tenaciously than water, and it is thus not so potent for producing a rapid effect.

Undiluted liquid carbolic acid may in some cases be required. This is obtained by liquefying the crystals by the addition of a few drops of water. This is chiefly used for injecting nævi, varicose veins, &c.

A solution of carbolic acid in *methylated spirit* or in rectified spirit, in the proportion of 1–5, is used for the purpose of purifying wounds inflicted some twenty-four or thirty-six hours before coming under treatment.

Carbolic oil is employed of various strengths, generally 1 in 5, 1 in 10, and 1 in 20, consisting of carbolic acid mixed with olive oil in the foregoing proportions.

Carbolic oil 1–5 is but rarely used, though it is occasionally applied as a dressing to foul wounds, for the purpose of purifying them.

Carbolic oil 1–10 is used as a dressing for wounds in the neighbourhood of the anus, penis, &c.

Carbolic oil 1–20 is used for oiling catheters or other instruments before introducing them into the bladder. It is well, however, to lay the instruments in 1–20 carbolic lotion for some time before using them, especially where there is any disease of the bladder.

There are various objections to these oily dressings. The

FIG. 5.—HAND SPRAY PRODUCER.

chief are, that the carbolic acid is very rapidly washed out by the discharge, that they are very dirty, and soon spoil india-rubber tissues.

The latter disadvantage is got rid of by the use of *carbolic acid and glycerine* in the proportions of 1–5 and 1–10. This is now employed as a dressing in the circumstances in which the oil has been generally used.

A *spray* of carbolic acid is generally employed in order to

purify the atmosphere. This is obtained by driving a rapid current of air or steam through a horizontal tube so as to pass over the orifice of a more or less vertical one. In this way a vacuum is produced in the vertical tube, and the fluid at its lower end rises, and is expelled from the orifice in the form of spray. We have two forms of spray producers: one in which air is driven over the vertical tube—hand or foot sprays; and the other in which steam is employed—steam sprays. The hand or foot sprays produce a somewhat coarse spray, and the force required is such as soon to exhaust the individual employed. They are therefore very uncertain implements, and have now entirely given place to the steam spray producers where there is a steady current as long as the water in the boiler lasts. When the hand sprays are employed 1–40 solution is placed in the bottle. In the steam spray the 1–20 solution is used, because the steam, mixing with the solution, reduces its strength to 1–30 or 1–35.

FIG. 6.—THE ORDINARY STEAM SPRAY PRODUCER.

I need not describe in detail the steam spray apparatus, more especially as it can be easily obtained, of Sir Joseph Lister's pattern, from David Marr, High Holborn, W.C. It consists of the following parts: A boiler which contains water, and which is heated by a spirit lamp placed beneath it. The steam issues through a tube placed at an angle to another more upright one, through which the carbolic acid lotion 1–20, which is placed in the glass retort, is sucked up. This 1–20 lotion, mixing with the steam, makes a solution of 1–30 to 1–35. The carbolic acid solution passes through a sponge at the bottom of the upright tube, which filters it, and thus prevents the minute orifice of the tube from becoming

choked up by coarse particles. These sprays are of various sizes, and the largest ones have two nozzles, which may be used singly, or together where the field of operation is large as in ovariotomy (see fig. 8).

FIG. 7.—STEAM SPRAY PRODUCER, SHOWING THE LAMP AT PRESENT IN USE.

It consists of a small flame, which plays on a plate of metal attached to a hollow central tube containing a wick, and perforated by holes at the top. The heat is communicated to the wick—the spirit volatilises, and burns as it escapes from the top of the tube. The hole in the plate allows the flame of the small wick to pass up and light the spirit vapour, which passes out through the holes at the top of the central tube. The cap, which is placed over the lamp when not in use, and the boiler and vessel for the carbolic acid, are indicated by dotted lines.

Carbolised catgut is used for ligatures and sometimes for stitches. Formerly it was prepared by immersion in carbolic oil, but three years ago [1] Sir Joseph Lister introduced a new catgut made by the use of solutions of chromic and sulphurous acids, which is stronger and not so rapidly absorbed as the older kind.

[1] *Lancet*, February 5, 1881.

The catgut is kept dry on reels in the trough figured below, and an hour or two before the operation 1–20 carbolic lotion is poured into the trough, filling it about half full, so that as the reel is turned the catgut is immersed in the lotion.

In order to have a supply of gut always at hand, Sir Joseph Lister has devised the catgut holder shown in the accompanying figure (fig. 10). The gut is wound on a reel which is carried in a German silver case. The gut is soaked in 1–20 carbolic lotion before being used. Sometimes the case is combined with a caustic holder at the other end.

FIG. 8.—LARGE STEAM SPRAY PRODUCER WITH DOUBLE NOZZLE FOR OVARIOTOMY, &c.

Carbolised silk is often used for sutures, and is prepared as follows: Nine parts of beeswax and one part of carbolic acid

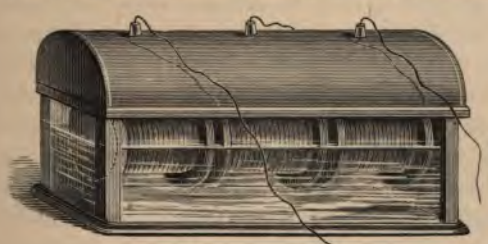


FIG. 9.—TROUGH FOR CATGUT.

are melted together. Silk thread of various sizes is steeped for some minutes in this mixture, till it is thoroughly impregnated with it. As the thread is taken out, it is drawn through a cloth in order to remove the superfluous wax. The wax holds the carbolic acid, makes the thread more useful, and fills up to

some extent its interstices, thus preventing it from becoming soaked with fluids. The carbolised silk thus prepared is kept permanently in stoppered bottles, or wrapped in carbolic gauze.

FIG. 10.—LISTER'S POCKET CATGUT HOLDER.
A, Holder complete. B, The reel on which the catgut is wound.

It must not be steeped too long in the lotion before being used, because the threads become opened out. If the thread be properly kept, the interior is aseptic or even antiseptic, and a short immersion in 1–20 carbolic solution is apparently sufficient to destroy any septic dust adhering to its exterior.

In order to protect healing wounds from the irritation of carbolic acid a special material is employed termed the *Protective*. This consists of oiled silk coated with copal varnish. When this is dry a mixture of one part of dextrine, two parts of powdered starch, and sixteen parts of cold watery solution of carbolic acid (1–20) is brushed over the surface. The rationale of this method of preparation is the following: Oiled silk alone is better for the purpose of a protective than gutta-percha tissue, because carbolic acid does not so readily pass through it. It does, however, do so, and therefore copal varnish, which is almost absolutely impermeable to carbolic acid, is added. As, however, the fluid collects on this as on a duck's back, leaving intervals between each drop on which dust may fall and escape the action of the acid, the dextrine solution is added, and the result is that when moistened the whole surface of the protective remains uniformly wet. The use of the carbolic acid in the dextrine solution is not to add any carbolic acid to the protective, but because it is better than water for enabling the dextrine to adhere to the varnished oiled silk. For the same reason the powdered starch is added. The

original carbolic acid flies off very quickly from the protective, leaving a material containing no antiseptic in its substance.

Carbolised gauze is the material generally employed as a dressing to guard against the entrance of causes of fermentation. The gauze used is ordinary fine unbleached tarlatan washed and dried. This is impregnated in various ways with one part of crystallised carbolic acid, four parts of common resin, and four parts of paraffin. These materials mixed together are added to an equal weight of unprepared gauze. The larger dressings are kept after use and sent back to the manufacturer, who washes and recharges them. In this gauze the carbolic acid is the only active agent; the resin is used to hold the acid, *i.e.* to prevent it from being washed out too soon by the discharge, while the paraffin is employed to lessen the adhesiveness of the resin. The gauze ought to be kept in a tin box closing tightly, to prevent evaporation of the carbolic acid. It is used either in the form of folded dressings, loose gauze or bandages.

In order to prevent the discharge from soaking directly through the dressing, *macintosh cloth* is used. This is cotton cloth with a thin layer of india-rubber spread on one side. It is placed outside the gauze dressing. As a rule one layer of the gauze comes outside it, partly in order to keep it in position, and partly also, in case any hole should exist in the macintosh, to have a little antiseptic material outside. Care is taken that the side on which the india-rubber is spread goes next the wound, for if the other side be placed inwards it absorbs the discharge, and, not being itself antiseptic, becomes in reality a piece of impure cotton in the interior of the dressing, and may thus communicate putrefaction inwards. The macintosh itself also gets spoilt when so used. The dressing consists of a piece of gauze of sufficient size folded in eight layers, beneath the outer layer of which the macintosh cloth is placed.

Sponges are washed after an operation, and are then kept soaking till required in a jar containing carbolic acid 1–20. During an operation they are washed in 1–40 carbolic acid lotion.

These sponges often become filled with fibrin, and thus rendered more or less useless. It is very difficult to remove this fibrin by washing. Sir Joseph Lister, therefore, after an operation places the sponges in a tank containing water. Putrefaction of the fibrin occurs, and after some days the sponges can be easily cleansed. They are then placed till required in the 1–20 carbolic solution.

When the wound becomes quite superficial, various preparations of Boracic Acid may be employed with advantage.

Boracic lotion is a cold saturated solution of boracic acid ($B_2O_3 3H_2O$) in water. This acid is soluble in 25 to 30 parts of cold water, and in very much larger proportion when the water is boiling. It is convenient to tinge this solution with litmus in order to distinguish it from the carbolic lotions.

Boracic lint is ordinary surgical lint soaked in a hot saturated solution of boracic acid and then hung up to dry. About half its weight consists of crystals of the acid. This is also stained with litmus.

Boracic ointment is employed in certain cases. Two strengths are commonly used, called full strength and half strength; the former being applied to wounds where cavities exist, the latter to superficial wounds which one wishes to heal rapidly.

The following is the best formula for the full strength :—

Make a basis of 2 parts of paraffin to 1 part of vaseline.
Take of this 5 parts.
„ boracic acid, 1 part. Mix. Spread on thin cotton cloth.

The half strength contains half the quantity of boracic acid.

Salicylic acid cream is used for applying around a wound when a dressing is to be left on for some days. It prevents irritation by the discharge. It formerly consisted of salicylic acid crystals mixed with 1–20 carbolic acid lotion in sufficient quantity to form a creamy fluid. This is apt to separate into two layers, and therefore it is better to make a cream by mixing salicylic acid with glycerine so as to form a paste. This latter cream remains of uniform consistence, and is easily applied. For

this purpose Sir Joseph Lister uses glycerine and carbolic acid 1–10.

The formula for *Salicylic ointment* is—

Of the same base as is used for boracic acid . .	29 parts
Salicylic acid	1 part.

For the purpose of purifying sinuses, putrid ulcers, &c., a solution of *chloride of zinc* is used of the strength of 40 grs. to the oz. of water. This is either applied on lint to the whole surface of a wound, or it is injected by means of a syringe and catheter into all the deep parts of the wound, care being taken to provide free exit for the fluid injected. If the exit of the solution is obstructed, it may pass into the tissues and cause gangrene.

Iodoform is now applied to the surface of ulcers, and answers the same purpose as the chloride of zinc solution, while it causes no pain.

Carbolised cotton wool is used in some cases of gangrene. It is obtained by soaking pure cotton wool in a 1 per cent. solution of carbolic acid in ether. The cotton is then dried and used immediately.

CHAPTER V.

ASEPTIC SURGERY—(*continued*).

Example of an aseptic operation: Purification of the skin—Fingers—Instruments: Spray—Precautions—Probable errors, and mode of remedying them: Guard: Ligature of arteries: Drainage of wounds—India-rubber tubes—Catgut drains—Horse hair—Decalcified bone tubes (Neuber's and MacEwen's): Sutures: Button stitches—Stitches of relaxation—Stitches of coaptation—Aseptic strapping—Protective: Deep dressing: Loose gauze: Gauze dressing: Elastic bandage. CHANGING THE DRESSINGS—Time—Method. TREATMENT OF ULCERS—Purification of the sore: Boracic dressing: Boracic and salicylic ointment: Boracic poultice.

HAVING described the materials employed in aseptic surgery we must now consider how they may best be employed. Take as an example of an operation the removal of a fatty tumour.

The skin over the tumour, and for some distance in the vicinity, is thoroughly purified from any active dust by washing it well with a solution of carbolic acid 1–20. This washing is now generally done an hour or two before the operation, and a cloth soaked in the 1–20 lotion is bandaged on the part. In very important operations, as in joint operations, opening psoas abscess, &c., the skin is washed on the previous day, and a soaked towel is applied and kept on during the night. The instruments are also placed in 1–20 carbolic lotion, if possible, for an hour or longer before use. The surgeon and his assistants wash their hands thoroughly in 1–40 lotion, or in important operations in 1–20. The patient having then been brought under the influence of chloroform or other anæsthetic, a towel is arranged close to the tumour, generally on the part of the table between the operator and the patient, which towel has been well soaked in 1–20 carbolic lotion, and is meant as

an antiseptic basis on which instruments may be laid during the course of the operation without any fear of their contamination. This towel is so arranged as to be within the cloud of spray. A spray being now made to play over the part from a convenient distance, the surgeon makes his incisions, removes the tumour, ties the vessels with catgut, introduces a suitable drain, stitches up the wound, and applies a piece of protective but little larger than the wound—the protective being of course dipped in the 1–40 carbolic solution. Outside this is placed a piece of wet gauze, consisting of several layers of loose gauze which have been soaking for some time in the 1–40 carbolic solution. This wet gauze and protective are called the *deep dressing*. The wet gauze must overlap the protective in all directions. Then any remaining hollow is filled up with loose gauze, and outside the whole a gauze dressing is fixed. This dressing consists of a piece of carbolic gauze of suitable size, folded in eight layers, and having the macintosh placed beneath the outermost layer, with the india-rubber side inwards. The dressing is fixed by means of a bandage, and when this is accomplished the spray may be stopped. Then around the edge of the dressing an elastic bandage is applied so as to keep the edge constantly in contact with the body, and to allow no interval to occur between the dressing and the skin during the movements of the patient. The elastic is carefully fixed to the edge of the dressing by means of safety pins.

In the after progress of the case the dressing is changed according to the amount of discharge, though in no instance is it left longer than eight days.

Such is, very briefly, a sketch of the ordinary method of performing operations aseptically. I shall now consider each step in detail, and point out the most frequent sources of failure in carrying out the method; for it must always be borne in mind that the whole operation, as far as regards the avoidance of putrefaction, requires as much care as if it were an experiment performed in a laboratory on putrescible fluid contained in glass vessels.

The first thing, then, is to purify the skin in the neighbourhood of the seat of operation. This is necessary, because the skin is covered with dust. The natural grease of the skin is not easily removed by simple washing, and it protects the septic particles present beneath it and in the hair or sebaceous follicles. This purification of the skin is carried out by washing it well with 1–20 carbolic lotion, the antiseptic being allowed to act for some time. It is well, as I have said, having first washed the neighbourhood thoroughly, to apply over the seat of operation a large cloth or towel soaked in 1–20 solution, and to allow this to remain on the part for an hour or more if this is possible. Where the epidermis is thick, or where there is any putrid matter present, it is best to apply this towel on the day before the operation. The carbolic acid has a wonderful power of penetrating grease or epidermis; and if time be given for it to act it is unnecessary to wash off the grease beforehand. If the wound is to be in the neighbourhood of hair, as in the axilla or near the pubis, the part must be shaved, and then well soaked with the carbolic lotion.

The errors in the purification of the part may be that the skin is not purified at all, or that it is washed with water; or, as I have seen, the operator simply allows a carbolic spray to play over it for a minute or two, and is satisfied with this; or he merely rubs the surface with his wet finger. This purification must, however, be done thoroughly, for every hair follicle and gland duct may contain causes of putrefaction. Carbolic oil is used by some instead of the watery solution to purify the skin. This is a great mistake, for oil has a much greater affinity for carbolic acid than water has, and therefore the carbolic acid in the oily solution does not act with the same rapidity as the watery solution. The inefficiency of the oily solution for this purpose will be at once understood on referring to the remarks in the last chapter.

At the same time the operator and his assistants purify their hands. This must also be done thoroughly, and the folds of skin about the nail more especially must be well cleansed with

the lotion. In an important operation, as in an operation on a joint, it is well to use 1–20 carbolic lotion for this purpose, so as to avoid the chance of a particle escaping; but in ordinary operations 1–40 is quite sufficient. This purification of the hands is only too apt to be a sham, no care being taken about the nails and folds of skin. The 1–20 is not used in all cases, because 1–40 is really sufficient, and the stronger solution is apt to benumb the hand.

The instruments are purified by immersion in 1–20 carbolic lotion before the operation. A tin or porcelain trough filled with the 1–20 solution is employed for this purpose, the instruments being placed in it some time before an operation (fig. 11). The instruments are not merely dipped; they must remain in the

FIG. 11.—PORCELAIN TROUGH CONTAINING INSTRUMENTS SOAKING IN CARBOLIC LOTION.

lotion for some time, because the carbolic acid requires a little time to act on the grease or dirt on them. The teeth of toothed instruments ought also to be cleaned thoroughly, and forceps locking by catches ought to be widely opened, so as to allow the solution to come in contact with all parts. The whole instrument must be immersed, for if only the point be purified it may happen that the impure handle is inadvertently brought into contact with the wound during the course of the operation.

The errors most likely to occur are either that during the course of the operation an instrument not previously in the tray is used without any attempt at purification, or that the instrument is imperfectly purified or only part of it cleansed. I have

seen the danger of partial purification more than once exemplified. Thus I have seen the blade of a knife alone purified, and the surgeon in the middle of the operation use the unclean handle to separate the tissues. Other errors in the manipulation of instruments will be referred to presently.

The spray is very important in many cases, for it provides an atmosphere in which instruments, &c., may be kept without danger of contamination. In order to have a wide and large antiseptic area in which to work, the spray ought not to be too near, about six or eight feet or more being a suitable distance for a good spray. Care must be taken that the spray is not blown off the part by draughts or by people moving about. The spray is most necessary in opening abscesses or in stitching up wounds, for, to take the latter case, as the wound is not syringed out after the stitches are inserted, septic air may be inclosed in the cavity of the wound, and may give rise to putrefaction if the spray has not been playing over the wound while the stitches were being introduced.[1]

During the course of an operation any instrument which has been once purified, if kept in the spray, even though covered with blood, remains pure, and may be introduced into the wound without hesitation. The same is the case with the hands of the operator or assistants; and therefore the dresser, in handing instruments to the surgeon, *must hand them into the spray* (fig. 12). If in the course of the operation the surgeon reaches his hand or an instrument out of the spray for any reason whatever, it must be repurified before being put into the wound. For this purpose there is generally a basin of 1–40 carbolic lotion placed close to the operator in the line of the spray, in which fingers, instruments, &c., may be re-purified by momentary dipping. When instruments are laid down out of the spray, or, in the spray, on a blanket, they must

[1] As the result of recent observations it is open to question whether the spray can really fulfil the object in view of destroying all the bacteria in the air. It, however, constantly bedews the surface of the wound with carbolic lotion, so that if living organisms do fall in the action is continued, while it will hinder their development if they should not be killed. It also keeps the hands and instruments constantly moist with the lotion.

be repurified before being used again. To provide a basis on which instruments may be laid, the carbolised towel is

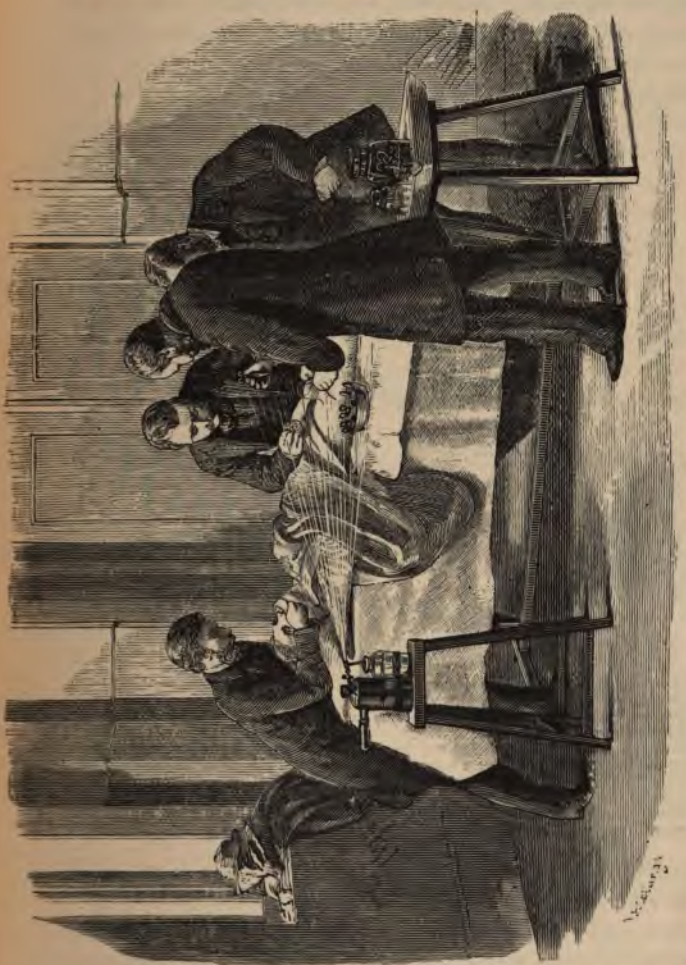


FIG. 12.

This figure represents the general arrangement of surgeon, assistants, towels, spray, &c., in an operation performed with complete aseptic precautions. The distance of the spray from the wound, the arrangement of the wet towels, the position of the trough containing the instruments, the position of the small dish with the lotion, the position of the house surgeon and dresser, so that the former always has his hands in the cloud of the spray, and the latter hands the instruments into the spray and various other points, are shown.

arranged before the operator as formerly described, and the blankets in the neighbourhood are generally also covered up

with wet towels, so as to avoid the chance of the instruments being laid on the blankets (see fig. 13). Should the operator, during the course of an operation, wipe his hands in a dry towel, or touch any unpurified substance, he must remember to wash his hands in 1–40 carbolic lotion before re-introducing them into the wound.

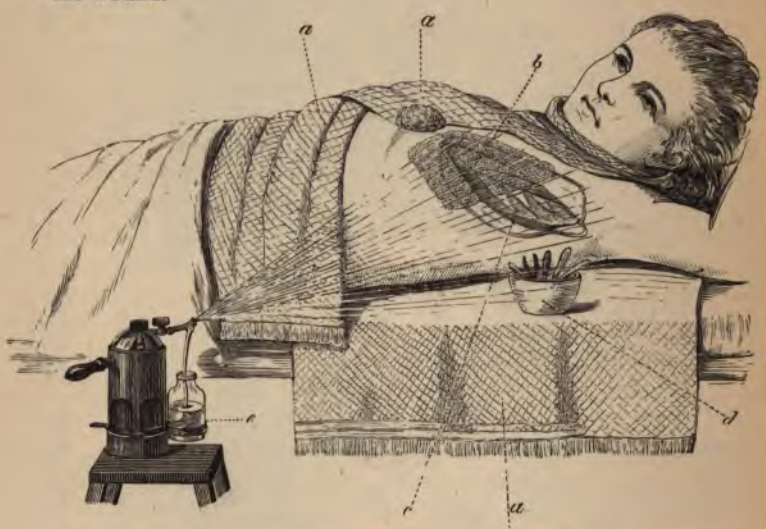


FIG. 13.—TO SHOW THE ARRANGEMENT OF TOWELS, &C., IN A LARGE OPERATION.

a a a are three towels which have been soaked in 1–20 carbolic lotion, so that instruments &c., may be placed on them without fear of contamination. Thus a small sponge will be seen on the upper one. *d* is the dish containing 1–40 carbolic lotion which always stands before the operator, and in the line of the spray. In this he places the instruments which are not being used, and in it he repurifies his hands or instruments if they have been removed from the cloud of spray. In this particular instance we have a large wound, *c*, to deal with—one so large that a single spray, unless of large volume, may not cover it completely. Hence a piece of *guard*, *b*, soaked in carbolic lotion is thrown over the front of the wound while the surgeon is attending to the axillary part, or *vice versâ*.

These precautions seem on the one hand self-evident, while on the other they seem so burdensome to remember that they are often neglected by self-sufficient surgeons. And yet it is by the neglect of these, rather than by error in any other part of the Listerian method, that mistakes arise and failures occur. Many people think that the spray is the essential part of the treat-

ment, and neglect the precautions as to constant purification of instruments, &c., and when their cases go wrong they say that the principle is incorrect. And yet one thoroughly acquainted with the Listerian method will readily detect the loopholes, and the general loophole is the omission of some of the precautions with regard to purifications of fingers, instruments, &c. Thus I have seen a surgeon with considerable experience in aseptic treatment, during the course of a difficult operation wipe his hands with a dry towel and immediately introduce them, covered with the dust from the towel, into the wound. The patient died of septic poisoning. Now many surgeons might have said, 'I used the spray; I used all precautions; my instruments were soaking; my hands were purified:' forgetting this one little incident. When the point was mentioned, however, the mistake was at once seen. People are too apt to trust to the spray as sufficient, and to speak of aseptic or Listerian surgery as treatment by the spray. This is a great and often fatal mistake. Of all the precautions required by Sir Joseph Lister, that of purifying the air by means of a carbolic acid spray is the least necessary, for there are but few septic particles present in the atmosphere, and even though some of them fall on to a wound they may be rendered inert by washing the wound with carbolic lotion. It must always be remembered that Sir Joseph Lister carried out aseptic treatment for years with great success without any spray; and if at the present time he were compelled for any reason to give up some one precaution, he would at once throw aside the spray, as that one which is least necessary, and which could be the most readily dispensed with. At the same time the spray is an immense convenience in many cases, more especially in abscesses, empyemata, in stitching up wounds, &c.; and it saves the necessity of applying a great deal of carbolic acid to wounds by irrigating them, with the consequent irritation and risk of carbolic-acid poisoning.

To return to the errors which may arise in this part of the treatment. It may be that the spray is too near, and that thus the cloud is so narrow that the surgeon is constantly getting

his hands or his instruments out of it, and forgetting to repurify them. There are other disadvantages when the spray is too near. Thus it is very wetting, and the hands of the surgeon and the wound are unnecessarily irritated by the carbolic acid. If too near, the opaque spray also obscures the field of vision. Other sources of error are that instruments may be used which have never been purified, which have been only imperfectly purified, which have after their use lain about outside the spray or on blankets, &c.; or it may be that the carbolic acid gets exhausted in the spray bottle, or that for some other reason the spray does not act properly.

What is to be done should any of these accidents occur? Suppose that an impure instrument or finger be introduced into the wound, that wound must be at once thoroughly washed out with 1–40 carbolic lotion. This is a bad thing for the wound, because it irritates it, and may prevent healing by first intention; or by causing a much larger quantity of discharge than usual, the gauze dressing may be so saturated with the discharge as to render it unable to prevent the spread of putrefaction inwards. Therefore it is better to use the spray, and to take all the precautions before mentioned. Should the spray stop, the wound must be washed out just as in the former case, and then, till the spray can be set agoing again, the wound is covered with a piece of rag soaked in carbolic lotion.

This piece of rag, called the guard, ought to be always present in the basin by the side of the surgeon, and when there is any indication that the spray is failing, or should it be advisable to stop the spray for any reason, this is thrown over the wound for the time being. Should any time elapse before the spray is again ready for use, this guard must be repeatedly moistened with carbolic acid lotion 1–40.

Where the wound is very large it may be protected during the operation either by having two sprays, or by covering up the part of the wound which is not being operated upon by a guard (see fig. 13).

The arteries are ligatured with catgut. This catgut is

generally employed of three different sizes. The largest is used only for large vessels or for stitches; the medium for medium-sized vessels, or for vessels in inflamed or dense tissues where considerable force is required to constrict the vessel, or

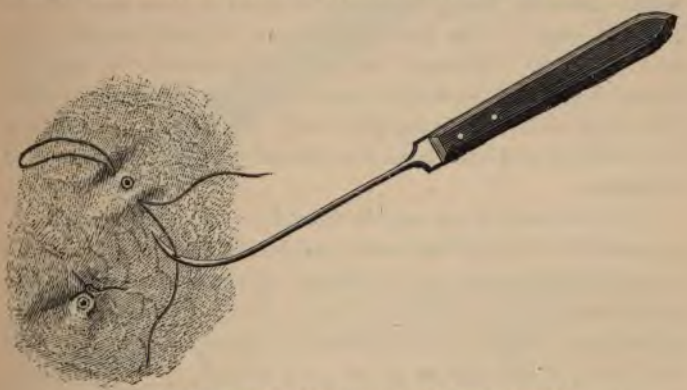


FIG. 14.—METHOD OF TYING VESSELS IN DENSE TISSUES.
(After MacCormac.)

for stitches; the small or fine catgut is that ordinarily employed for the smaller vessels. The vessel having been securely tied, the catgut is cut short and gives no more trouble. It is well to tie all the visible bleeding points, because a little oozing of blood may give trouble afterwards from tension. If the vessel be situated in dense tissue, so that a ligature cannot be applied around it, a needle carrying a double catgut thread should be passed through the tissue and tied on each side of the vessel (see figs. 14 and 15). Where the bleeding is from a tear in a large vein, and where it would be dangerous to ligature the vessel, I have seen the following

FIG. 15.—ANOTHER METHOD OF TYING VESSELS IN DENSE TISSUES.
(From Esmarch.)

method adopted by Sir Joseph Lister. In removing some cancerous glands from the axilla, a small vein was torn away from the axillary vein at their junction, making practically a longitudinal rent in the axillary vein. Taking a fine curved needle and the finest catgut, he stitched up the rent by the glover's suture. The patient recovered without the slightest bad symptom. There was no pain in the wound, nor swelling of the arm, &c. In another case where the longitudinal sinus was injured in trephining the skull, the wound was plugged with catgut, and the patient recovered without any untoward symptom.

The drainage of an aseptic wound is the point next in importance to keeping the wound aseptic. For if the blood and serum which collect in the interior of the wound within the first twenty-four or forty-eight hours do not get free exit, they give rise to tension, and tension gives rise to inflammation, and the latter, if allowed to go on long enough, to suppuration; and thus the rapid healing of the wound is prevented though the patient is not as a rule subjected to any danger to life. To avoid these consequences Sir Joseph Lister has paid very special attention to the drainage of wounds. There are two main ways in which this may be done—drainage through tubes, or drainage by capillarity. The former is the most universally applicable and the most certainly successful.

Drainage by means of tubes is the form of drainage first used by Sir Joseph Lister, and, as just stated, is that which is most universally applicable. The tubes generally employed are the india-rubber tubes introduced by Chassaignac, though of late the kind of rubber has been altered, that now used being red rubber, which contains no free sulphur. By the use of these red rubber tubes disagreeable smells and blackening of the protective, which often occurred when the black tubes containing free sulphur were employed, are avoided. These tubes have round holes cut in them at short intervals, the diameter of each hole being about one-third of the circumference of the tube. At the outer end the tubes are cut flush with the surface of the skin—straight

across if the tube goes directly downwards, or with varying degrees of obliquity according to the direction which the tube

FIG. 16.—ORDINARY OBLIQUE-ENDED DRAINAGE-TUBE READY FOR USE.

takes (fig. 16). The tube must not project beyond the surface, for if it does its orifice gets compressed by the dressing, and the exit of fluid is prevented. To keep the drainage-tube from slipping in, two threads of carbolised silk are fastened into it at its orifice, and tied in a knot. This knot, held between the

FIG. 17.—DRAINAGE-TUBE WITH MASSES OF GAUZE IN THE LOOPS OF THREAD.

dressing and the skin, retains the tube in position. In some cases, however—as, for example, in empyema—the tube might slip in in spite of these threads, and therefore it is well to fill

up the loops with strips of gauze soaked in the carbolic lotion (fig. 17). These absolutely prevent the tubes from slipping in. These tubes are always kept in a large vessel containing 1–20 carbolic acid solution, and are thus always ready for use. When a tube is altogether removed from a wound it is not thrown away, but is washed and put into the bottle with the other tubes, and used for another case. These tubes vary in size, according to the size of the wound and the amount of discharge expected, and are arranged so as to drain the parts of the wound which form cavities, or from which the greatest amount of discharge will come. It is not necessary that their orifices be dependent, though it is of course better that they should be so. It is not essential, however, because the fluid, as it forms, wells out, and, not being putrid, that which lies at the bottom of the drainage-tube does not cause irritation. In cases where the most dependent opening would be near sources of putrefaction, it is well to have the drainage-tube in another part of the wound, even though it be not so dependent. Thus in inguinal hernia the tube would no doubt be in the most dependent part if its orifice were close to the pubis, but as that would be much too near sources of putrefaction, such as the vagina and penis, the orifice of the tube ought to be at the outer angle of the wound (see fig. 18). In a large wound it is well to have more than one tube; and it is better to have two smallish tubes in any case, rather than one large one, because on the day after the operation one of these tubes

FIG. 18.—INCISION FOR INGUINAL HERNIA, STITCHED, SHOWING THE POSITION OF THE DRAINAGE-TUBE AT THE OUTER ANGLE OF THE WOUND.

may be removed altogether; whereas if a large one were pulled out in order to insert a smaller, there would be the greatest difficulty in introducing either. No tube which one wishes to put back again should be removed till the third day, on account of the difficulty of returning it. By that time, however, it lies in a channel in the blood-clot or lymph, and slips back easily. Fig. 19 represents forceps introduced by Sir Joseph Lister, and

FIG. 19.—SINUS FORCEPS.

called 'sinus forceps,' which are of the greatest service in inserting drainage-tubes. Generally on the third day half the tube is cut off, and it is reduced in length at subsequent dressings till it becomes no longer necessary. No exact rules can be given for shortening or leaving out the tube. This must simply be a matter of experience, guided by the amount of discharge and the tendency to accumulation or otherwise. Should tension occur, a larger and longer tube ought to be at once introduced.

A point which has always seemed to me of great importance in connection with the use of these tubes, and one which has apparently been overlooked, is the following. A tube is taken out of carbolic lotion at some distance from the spray, is carried through the air, and then directly introduced into the wound. I can hardly believe that when a large tube is taken out of the lotion there would be sufficient vapour of carbolic acid in it to destroy any septic dust which might get into its interior, for a considerable mass of air must take the place of the fluid, and this amount of hospital air may often, as I have found by experiment, contain causes of putrefaction. Of course when passing through the spray this air may be displaced or purified, and also when introduced into the wound a considerable amount

of it would be forced out; while at the same time there is a good deal of carbolic acid present, and purification in one way or another would probably occur. And, further, the purifying power of healthy living tissues must be taken into account. But in the case of a cavity, purification in any of these ways may not happen, and putrefaction may result. My suggestion therefore is always to take the tubes out of the lotion *in* the spray, and then the air which enters them will be air previously acted on by the spray.

Drainage by capillarity was introduced by Mr. John Chiene,

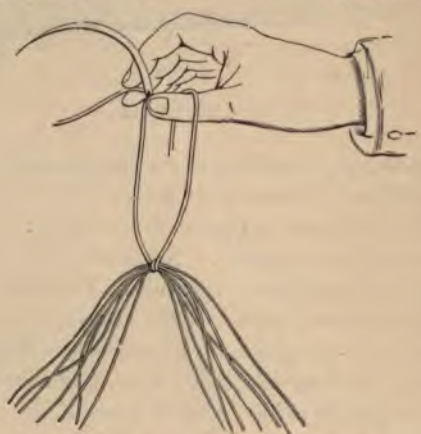


FIG. 20.—CATGUT DRAIN READY FOR INSERTION.

who was also the first to enunciate the principle of absorbable drains. For this purpose he uses catgut, and generally the finest threads. A skein of catgut, containing say twenty threads, is tied at its middle by a single thread of the same gut. One end of this thread is passed through a needle (fig. 20), and by means of this the centre of the skein is stitched to the deepest part of the wound (fig. 21). The skein is now broken up into bundles of five or six threads each. One bundle comes out at each angle of the incision, and the other bundles at intervals between the stitches (fig. 22). More than one skein may be

required in a large wound. This catgut becomes absorbed, and never requires to be removed. In five or six days the ends which hang out drop off, and little granulating sores are formed which heal in a few days. In this method the serum escapes by capillarity, and by distributing the threads over various parts of the wound the true principle of drainage is carried out; for, as pointed out by Mr. Chiene, in draining a field one does

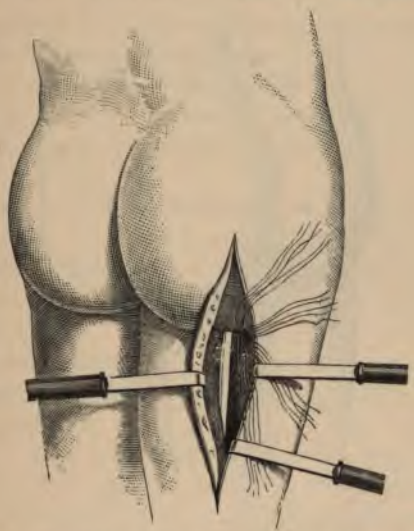


FIG. 21.—OPERATION FOR STRETCHING THE SCIATIC NERVE.

Catgut drain stitched to the deepest part of the wound, beneath the gluteus maximus, and broken up into four separate bunches.

not have one large drain going from one end of the field to another: on the contrary, the field is traversed by numerous small drains. And so, in Chiene's method of draining wounds, we have a number of small drains traversing the wound in several directions. In this method there is no trouble about pulling out the drain, and no necessity for changing the dressing simply to remove a tube; the drain disappears of itself. It is well to leave the ends of the catgut outside the wound as long

as possible, so as to get a siphon action, and care must be taken not to break up the bunches of catgut outside the wound, for the capillary action occurs in the intervals between the threads when they are closely apposed.

The objections urged against this method are, firstly, that in large wounds it is not sufficient and that the catgut becomes a pulpy mass, and when in large quantity takes a long time to

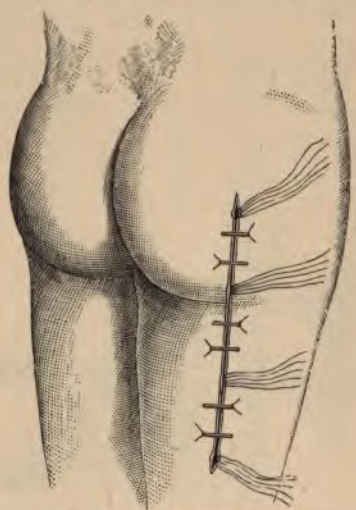


FIG. 22.—THE SAME WOUND STITCHED.

The bunches of catgut coming out at intervals between the stitches. (The wound has been exaggerated, and the threads of catgut separated, in order to show the method more clearly. The threads of catgut ought to lie in close apposition, for it is the intervals between the threads which act as capillary drains.)

organise. Not only may it be insufficient at first, but it may become absorbed too soon—before, indeed, a drain of some kind can be dispensed with.

Now these objections rest in great part on the fact that the drain is often improperly employed. If, for instance, it be not stitched to the deepest part of the wound, the catgut may slip and the deeper parts may not be drained; and again, if a large bundle of it be used, coming out at one part of the wound only,

it does become a pulpy mass, and takes a long time to organise. But this is not the method recommended by Mr. Chiene, for he says that only five or six threads ought to be brought out at each place. There is, however, no doubt that in some cases it is absorbed too quickly, and this was the real objection to the use of this method when we had only the catgut prepared by the old method, though even with it, if the gut was well prepared and old, the drainage was often very satisfactory. This difficulty is lessened by the use of the chromic catgut; the only difficulty now is that the drain lasts too long. Of course, if necessary, the ends of the drain can be cut off, when it has served its purpose, below the level of the skin, and then, even though the internal part be not all absorbed, the wound can heal completely.

Catgut can only drain fluids such as blood or serum; it cannot drain pus. It is, moreover, unsuitable in cases of chronic abscess, where we have only a serous discharge, because the catgut is absorbed at the surface long before a drain can be dispensed with.

If the wound is very large it is best to introduce tubes as well as catgut drains at first. The tubes may be removed in twenty-four hours.

Instead of catgut, horse-hair has been a good deal used. This is simply laid into the wound in the situation where it seems most required. It is diminished by degrees, threads being taken out at various intervals of time. It has an advantage over catgut in draining joints, for no part of the drain remains in the interior of the joint, while portions of catgut do. Further, it is not absorbable.

But it has the same disadvantages as the drainage tubes, and it is not readily retained in the deeper parts of the wound. It is, however, preferred by Sir Joseph Lister to the catgut.

It is easy to re-introduce a horse-hair drain if necessary by proceeding in the following manner: A sufficient quantity being taken, the bundle is bent at its middle over a probe, and tied close to the probe by carbolised silk (fig. 23). In this

way, the probe being withdrawn, a blunt compact end is obtained which may be introduced into the wound with ease.

The principle of absorbable drains has also been applied by Dr. Neuber of Kiel [1] in his absorbable drainage tubes. These are tubes drilled in long bones, and then decalcified and carbolised. Holes are afterwards cut in the sides, and they are used like ordinary india-rubber tubes. These tubes are said to answer very well, though they are sometimes absorbed too soon, and sometimes last too long. They sometimes get soft and collapse about the third or fourth day, and thus, though not absorbed, become useless as a drain.

Dr. MacEwen [2] has lately somewhat modified Neuber's tubes. He uses chicken-bones, which are already hollow, and decalcifies

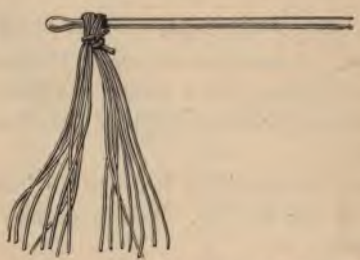


Fig. 23.—Method of Preparing a Horse-Hair Drain for Re-Introduction.

them. 'The method of preparation is as follows: The tibiæ and femora are scraped and steeped in hydrochloric acid and water (1 to 5) until they are soft. Their articular extremities are then snipped off with a pair of scissors; the endosteum is raised at one end and pushed through to the other extremity, along with its contents. They are then re-introduced into a fresh solution of the same strength until they are rendered a little more pliable and softer than what is ultimately required (as they afterwards harden a little by steeping in the carbolised

[1] 'Ein Antiseptischer Dauerverband nach gründlicher Blutstillung,' *von Langenbeck's Archiv*, Bd. xxiv. Heft 2.

[2] *British Medical Journal*, Feb. 5, 1881.

solution). When thus prepared they are placed in a solution of carbolic acid in glycerine 1–10. They may be used at the end of a fortnight from the time of introduction into the glycerine solution. Holes may be drilled in them with a punch, or clipped out with scissors.' These tubes are threaded with horse-hair before being introduced into the tissues. This hair helps to maintain the calibre of the tube during the first few days, and also itself acts by capillarity.

The average duration of MacEwen's tubes in the tissues was something over eight days. If, however, a tube is likely to be required for a longer time, it can be obtained by steeping the decalcified tubes in a chromicised instead of a carbolised solution. These resist the action of the tissues for two or three weeks.

The accurate stitching of the edges of the wound is another feature in aseptic surgery. In operating aseptically the same

FIG. 24.—LEAD BUTTONS FOR DEEP STITCHES.

A, The present form, described in the text. B, Form of button devised by Dr. Ogilvie Will (seen in section). C, The old form, where the wire was fastened by passing it beneath the button.

care need not be taken to remove as little skin as possible, as is necessary in wounds treated by other methods where swelling and inflammation of the edges are expected. One may take away a wide sweep of skin, such as would seem to render hopeless any attempt to bring the edges of the wound into apposition; and yet if the edges can only be apposed, and if the wound remains aseptic, union by first intention may be expected along the whole line.

Button stitches are employed to relax the edges of the

wound, and thus to leave the cutaneous margins free from the irritation which must occur if they are tightly drawn together. These consist of flat pieces of lead cut of an oval form and of various sizes, perforated in the centre by a hole through which silver wire is passed, and provided with two lateral wings round which the wire is twisted (fig. 24). (There are various forms of button suture, but all act on the same principle.) These are applied some distance on each side of the edge of the wound, and connected by strong silver wire drawn tight enough to permit the edges of the wound to come easily together. The number used varies according to the amount of tension. In order to bring the edges of the wound into actual contact,

FIG. 25.—WOUND AFTER REMOVAL OF MAMMA AND AXILLARY GLANDS, STITCHED.

To show the three kinds of stitches. The button stitches will be at once recognised; the thick stitches, of which three are represented, are the stitches of relaxation; and the remainder are the stitches of coaptation.

two sets of stitches are employed: silver wire stitches, which take a good hold of the tissues and are placed at regular intervals, termed stitches of relaxation; and in the intervals between these, in order to have the cutaneous margins accurately applied to each other, numerous stitches of coaptation, consisting of carbolised silk, horse-hair, or catgut (fig. 25). The speedy healing which occurs when the edges of the wound are accurately brought in contact, while they are at the same time, by the button stitches and the stitches of relaxation, freed from any tension, rewards the surgeon for the time spent in inserting a large number of these stitches of coaptation.

In taking out these stitches it is best to follow a reverse order to that of insertion. The first to be removed are the stitches of coaptation, while the stitches of relaxation are probably cut on the same day. Do not be in a hurry to remove the stitches where there was much tension in bringing the edges of the wound together. A week or ten days is time enough.

Should the wound gape, strapping may be employed, even under an antiseptic dressing. To render the strapping aseptic, it is immersed in warm carbolic lotion (one part of 1–20 and an equal part of boiling water) before being applied. This both renders it aseptic and also takes the place of the hot-water can for heating the strapping.

Having proceeded thus far in the aseptic operation—having tied the vessels, arranged the drainage, and brought the edges of the skin well together—we must now apply a dressing which shall prevent the occurrence of putrefaction till the case is again seen.

In applying a dressing we must in the first place be careful to make it as little irritating as possible to the young epithelium along the line of incision. The dressing usually employed is the carbolic gauze; and, to prevent the irritation of the healing edge of the wound by the carbolic acid, a piece of protective is interposed between the gauze and the wound. This protective is cut a little larger than the wound, and it is well to cover the buttons with a little bit also, in order to prevent the threads of the gauze becoming entangled in them. This protective need not extend over the orifice of the drainage tube, as its essential object is to protect the healing part from the irritation of the carbolic acid. The protective is also of use in preventing the dressing from sticking to the wound, and in preventing the formation of scabs, and the consequent possible retention of the discharge.

An error which is frequently made is to put on too large a piece of protective. There is nothing antiseptic in its substance, and it protects the discharge beneath it from the action of the

carbolic acid. Therefore if at any part it projects beyond or comes close to the edge of the dressing, it allows the causes of putrefaction to spread inwards beneath it, and prevents the carbolic acid from acting on this putrefying discharge. It is therefore a very good rule, having covered the wound with sufficient protective, to look on this protective as a wound, and to be as careful in having the gauze dressing overlap it in all directions as if it itself were the wounded surface. Where there is very little space for overlapping, as in inguinal hernia,

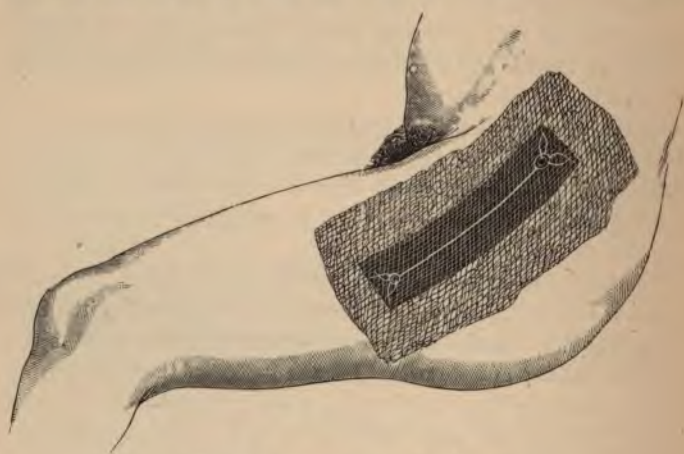


FIG. 26.—EXCISION OF THE HIP-JOINT.
Wound stitched; protective and deep dressing applied.

no protective ought to be applied. It is better to have somewhat slower healing than to have micro-organisms spread into the wound. As mentioned before, this protective is dipped in carbolic lotion 1–40 before being applied.

Outside the protective a piece of gauze wet in the carbolic lotion 1–40 is applied so as to overlap the protective in all directions. The reason for wetting the gauze is that dry gauze is apt to receive dust on its surface before being used, while at the ordinary temperature of the atmosphere but little carbolic

acid is given off from the gauze, certainly not enough to destroy immediately the activity of the septic particles in the dust. But if the piece of gauze applied next to the protective be moistened in the 1–40 solution, this dust is at once deprived of septic energy, and we apply over the wound a layer of pure and powerfully antiseptic material.

The piece of wet gauze and the protective go by the name of the deep dressing. This deep dressing may in some cases, and more especially where catgut stitches and catgut drains are used, be left for several days undisturbed. In this way the wound is not irritated by the application of carbolic acid to it every time the dressing is changed. If the deep dressing be thus left on, it must be remembered that the deep piece of gauze loses all its carbolic acid very soon, and that therefore it must be treated as a wound—*i.e.* in renewing the dressing this deep part must be overlapped in all directions by a piece of wet gauze, and that again by a dressing of suitable size.

In some cases it may be desirable to fix down the deep dressing with a piece of gauze bandage. If it be intended to leave on this deep dressing for some time it is well, before applying it, to rub the neighbourhood of the wound with the salicylic cream mentioned before. It sometimes happens that when a dressing is left on for many days together, the discharge becomes somewhat irritating, and the skin around the wound becomes excoriated. This is generally entirely prevented by the use of salicylic cream.

Having arranged the deep dressing in a suitable manner, any hollows which exist in the neighbourhood of the wound are filled up with carbolic gauze, and special masses of this material are placed where the greatest amount of discharge is expected. Outside this comes a large gauze dressing. In making the gauze dressing a piece of macintosh cloth with the india-rubber side uppermost should be laid on a table and sponged with 1–20 carbolic lotion; the gauze is laid on this. The gauze is folded in eight layers, or sixteen if much discharge is expected, and a piece of macintosh cloth of the size of the dressing is placed

beneath the outer layer, with the rubber side towards the mass of gauze. The size of this dressing varies according to the amount of discharge expected, but in all cases it must extend well beyond the deep dressing in all directions. Some special examples will be mentioned presently.

This dressing is fixed on with a suitable bandage. The gauze bandage is preferable to an ordinary bandage under certain circumstances. It is especially convenient in bandaging a stump next the skin to prevent retraction of the flaps, and also for fixing down the deep dressing. It also increases the amount of antiseptic material outside the macintosh if there happens to be a hole in it. But for ordinary use in fixing on dressings

FIG. 27.—DRESSING IN A CASE OF PSOAS ABSCESS OPENED ABOVE POUPART'S LIGAMENT.

To show the arrangement of the elastic bandage along the margins of the dressing.

very light and cheap bandages may be made from the ordinary thin muslin which is used as a guard. They do not stick to the skin as the gauze bandage is apt to do.

The dressing is pinned round its edge to the bandage. Care must be taken not to put pins through the macintosh at any part except at its edge. Pinholes through the centre of the macintosh simply defeat its object by permitting the discharge to come directly through the dressing. The object

of the macintosh is to make the discharge travel through a large extent of the gauze, and thus the same result is obtained as if a mass of gauze were applied over the wound, of the same thickness as the distance from the centre of the macintosh to its edge. If, therefore, there be a pinhole near the centre of the macintosh, the object of the latter is seriously interfered with. Accordingly, it is always the duty of the person who makes the dressings to examine the macintosh with the view of detecting any holes in it.

If the dressing is to be used as soon as it is made up, it is well to sponge the surface of the macintosh with 1–20 carbolic lotion before inserting it into the dressing. The same piece of macintosh may be used for a whole case, or for more than one—so long, in fact, as it does not become worn into holes. Two pieces of macintosh are generally provided for each case, and a dressing is always made immediately after the case has been dressed, and is ready for application at any time.

During the movements of the patient, the edge of the dressing might become separated from the skin, and air pass into the space thus formed. To prevent this, the German surgeons as a rule pack in salicylic jute or wool beneath the edge of the dressing. This may serve the purpose, but it is by no means safe. Sir Joseph Lister some time ago introduced the use of elastic webbing, which is of various breadths. It is better not to be too broad. It is put moderately on the stretch, and surrounds the edge of the dressing. Its general arrangement varies of course with the situation. It is not much used on the extremities, because the arm or leg is generally so fixed by means of splints that there is no chance of separation of the dressing.

The operation and first dressing having now been completed, the question arises when the dressing should be changed. It is only extremely rarely that it is necessary to change it the same evening. The only cases in which this is usually done are large empyemata or very large abscesses, and cases of amputa-

tion at the hip-joint, where the discharge of bloody serum is profuse, and where there is but little space for overlapping of the dressing.

As a rule, the dressing ought to be changed entirely on the following day, the deep part as well as the superficial. It is well to change the deep dressing in order to see that none of the stitches are too tight, and that the drains are acting properly. After the first day the deep dressing need not be touched, unless the patient is complaining of uneasiness, or unless the surgeon wishes to see the wound for the purpose of removing stitches or drain. If it is not necessary to disturb it, it may, especially

FIG. 28.—METHOD OF CHANGING A PSOAS ABSCESS DRESSING.

A, Hand of patient holding down the dressing over the wound. B B, Hands of surgeon lifting the lower edge of the dressing (C). D, The spray machine so placed that the spray passes in beneath the dressing as it is lifted.

where there is an organising blood-clot, be better not to do so, for that would only be to expose the wound unnecessarily to the irritation of the carbolic acid. If the deep dressing is not changed, great care must be taken to have an efficient spray playing over the part.

In changing the dressing the spray is used, and also 1–40 carbolic lotion, in which a piece of loose gauze and protective

are put before the dressing is begun. The elastic bandage is first removed, and then the patient or an assistant places his hand over the centre of the dressing while the bandage is being cut, so as to prevent the dressing being lifted up and air pumped in. Then the surgeon, having purified his fingers, and having turned on the spray, lifts the edge of the dressing carefully, taking care that the spray passes into the angle between the dressing and the skin (see fig. 28). Having removed the superficial dressing, he again dips his fingers, and then removes the deeper parts and exposes the wound.

If nothing is wrong, he immediately applies fresh protective and wet gauze, and then washes the parts round about, as far as the discharge has extended, with 1–40 carbolic lotion. The edge of the wound is not washed or exposed to the action of the spray longer than is absolutely necessary. It is well to apply the deep dressing at once, for in washing the surrounding parts one is apt to give the wound a final touch with the rag. Now this rag may contain some gross particles of putrid material (such as a crust of discharge from the exterior of the dressing, fæces, &c.), and thus putrefaction would be communicated to the wound. There is no necessity for cleansing the edges of the wound. Dirt, so long as it does not contain causes of putrefaction, does no harm; indeed, it rather aids the action of the protective; while to rub it away is to irritate and injure the healing edge—to produce a state of unrest. A fresh dressing is applied as before described.

Where there are two wounds in different situations, so placed that the spray cannot command both, each must be dressed separately, care being taken not to uncover the one till the other is at any rate protected by a deep dressing. The patient or assistant must keep his hand on the dressing over the one wound, while the other wound is being attended to.

The next dressing takes place on the following day at visit, if there is any discharge at the edge of the dressing or if the wound feels uneasy. If there is no discharge on the drawsheet,

and if the wound is free from pain, the dressing is not changed; and even though discharge should appear a few hours later, the dressing is not changed till next day at visit hour. The rule for changing the dressings is therefore: Change if discharge is through at the visit hour, or if there be any other reason for it; if not, leave the dressing till next day at visit, and then follow the same rule.

Never leave a dressing unchanged longer than a week. By that time most of the carbolic acid has passed off by evaporation; and therefore, if the discharge once came to the edge, putrefaction could spread inwards with great rapidity. And it would not be necessary for the discharge to appear at the edge in order to have putrefaction of the wound, for the sweat collecting beneath the dressing permits the multiplication of septic particles in it, and thus they may reach the wound. Where a dressing is to be left on for a week, it is well to use the salicylic cream in the way before described.

Such is the general method of using carbolic dressings; special modifications will be noticed presently. Let me pass on in the meantime to the general points as to boracic dressings.

Let us suppose that a patient is admitted with a foul ulcer of the leg: how is he to be treated? If he were to be treated with carbolic dressings, the ulcer would very probably remain foul, or even though it ultimately became free from odour, it would heal excessively slowly. Hence Sir Joseph Lister first purifies the sore, and then dresses it with boracic acid.

To purify the sore, chloride of zinc, 40 grs. to the ounce of water, may be used. This is applied thoroughly to the whole surface of the sore, and at the same time the surrounding skin is well purified by thoroughly washing it with 1–20 carbolic lotion, which is employed on account of its special power of penetrating the epidermis. When this has been done, a piece of protective, dipped in boracic lotion and slightly larger than the sore, is applied over it, and outside this one or two layers of moist or dry (it does not much matter which) boracic lint are

applied, of sufficient size to cover the protective well in all directions. There is the same objection here to allowing the protective to project beyond the edge of the dressing as in the case of the carbolic dressings. Lately, instead of applying the chloride of zinc solution, which causes considerable uneasiness, iodoform has been powdered over the whole surface of the ulcer, and it has been equally successful. The chloride of zinc or the iodoform need only be applied once; but should putrefaction not be eradicated, the application is repeated.

This dressing is changed next day, but afterwards, as a rule, it only requires to be changed every two or three days, or indeed at longer intervals, provided that there is not much discharge. That is to say, as there is a very large store of the antiseptic in the lint, and as it is but slightly soluble at the temperature of the human body, the discharge may go through the dressing many times without washing out all the antiseptic. At the same time, it is found as a general rule that the wound heals most rapidly when the dressing is changed once in three or four days.

At the changing of the dressing no spray is required. The bandage (which may be a common cotton bandage, if preferred) having been removed, the dressing is taken off and the wound well washed with boracic lotion. A final wash is given immediately before applying the fresh piece of protective and boracic lint.

This boracic dressing is not used for wounds which are not quite superficial, because the acid is not volatile, and because it is but a feeble antiseptic; but when once a wound has become quite superficial, it will heal more quickly if treated with boracic dressing.

In some cases, more especially where the sore is septic, or where the patient dresses it himself, boracic ointment is preferable to protective, and where the sore is healing, the half strength ointment is the best. Outside the ointment a piece of boracic lint is applied as usual. Of late, salicylic ointment has been used, and found to answer, as a rule, better than the

boracic. It is less irritating, and permits healing more readily. A eucalyptus ointment has also been employed quite recently, and has given good results.

When the effects of a poultice are wanted along with an antiseptic effect, the boracic lint is applied like water dressing. A suitable piece of the lint moistened in boracic lotion is applied, and outside this a larger piece of macintosh or gutta-percha, overlapping the lint in all directions.

CHAPTER VI.

ASEPTIC SURGERY—(*continued*).

Special dressings: *Head dressings*: *Neck dressings*: *Breast dressings —Abscess of mamma—Excision of mamma alone—Excision of mamma and axillary glands*: *Axillary dressings*: *Dressings on the limbs*: *Dressings for psoas abscess*: *Lumbar abscess*: *Hip-joint abscess*: *Dressings in cases of hernia and operations on the scrotum*: *Excisions of joints*. Aseptic treatment of abscesses. *Chief points to be considered in opening abscesses—Method of opening abscesses—Drainage of abscesses—After treatment of abscesses—Empyema—Perineal and anal abscesses.* Treatment of wounds produced accidentally; *Problem to be solved - Purification of wound—Further treatment of the wound.* Special wounds: *Compound fractures*: *Wounds involving tendons, nerves, &c.*: *Wounds of joints*: *Compound fractures of the skull*: *Penetrating wounds of the thorax*: *Wounds of the abdomen.* Putrid sinuses and wounds. Treatment of burns. Treatment of gangrene. Treatment of nævi and varicose veins.

I SHALL now describe the special methods of dressing and other precautions required in different situations.

In operating on the *scalp* the hair must be shaved for some distance around the wound, and the hair beyond ought to be soaked with carbolic lotion 1–20. If the incision be in the centre of the scalp, or, in other words, if there be a circle of hair all round it, it is better not to use protective at all, and it is well to powder the hair around thoroughly with iodoform or salicylic acid. The dressing in such a wound is fixed by the ordinary capelline bandage. Where the wound is more or less to one side, the dressing must extend downwards on the neck, and it is then well to have a narrow elastic bandage along the edges, more especially around the neck. In the neighbourhood of the ears, the various cavities in the ear, and the space behind it, must be filled up with gauze.

Neck dressings have nothing very unusual about them. The dressing must be fastened round the neck. It must be prevented from slipping down by a turn passing above the ears and around the forehead, and also by two vertical turns over the head, one transverse and the other longitudinal, these various turns being pinned together where they cross. To prevent the dressing from slipping up, turns are passed under the axilla. A narrow elastic bandage must be applied round the edge of the dressing in this situation, for the movements of the head are extremely apt to cause an interval between the skin and the dressing (figs. 29 and 30).

FIG. 29.

This figure illustrates the general arrangement of dressings on the neck. The arrangement shown here would do for any operation about the region of the sternomastoid behind or below the ear.

Breast dressings are very important; they are arranged in three different ways according to the size and extent of the wound.

No. 1.—Where an abscess of the mamma is opened, or where some small incision, not interfering with the form of the organ, is made, the dressing consists of an ordinary gauze dressing covering the whole mamma, some loose gauze being packed in in front and behind. This is fixed by turns of bandage passing round the body alternately above and below the organ, with straps over the shoulder. The arm is placed in a sling. The edges are fixed by elastic bandage (fig. 31).

No. 2.—Where the mamma has been removed and the discharge has become much diminished in amount, there may remain enough of room between the wound and the axilla for overlapping of the dressing. In order to fix the dressing and

keep it well up in the armpit, it is split vertically at the axilla, folded over, and pinned on the top of the shoulder. It

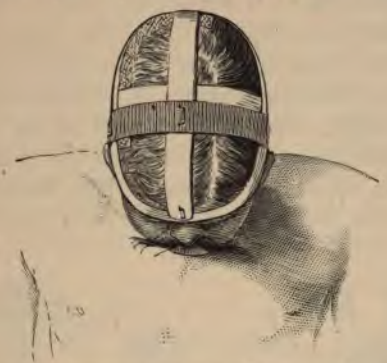


FIG. 30.—TO SHOW THE ARRANGEMENT OF THE TURNS OF BANDAGE ON THE HEAD SEEN FROM ABOVE.

FIG. 31.—DRESSING APPLIED IN A CASE OF ABSCESS OF THE MAMMA (BREAST DRESSING NO. 1).

FIG. 32.—BREAST DRESSING NO. 2.

The position of the drainage tube is indicated by dotted lines.

is then bandaged securely, and an elastic bandage applied around the edges (fig. 32).

No. 3.—Where the mamma and axillary glands have been removed, or for the first few days after excision of the mamma alone, this arrangement is not enough, for it does not leave sufficient room for overlapping. The arm must therefore be included in the dressing. This is accomplished most conveniently in the following manner: A large dressing is applied posteriorly, reaching behind as far back as the middle line, and folding over the arm so as to touch the thorax in front, the arm being applied to the side. This dressing must be broader than the length of the upper arm from the top of

FIG. 33.—CASE OF EXCISION OF THE MAMMA.

Back dressing lying ready for application; showing also the deep dressing and padding in the axilla and behind the arm.

the shoulder to the tip of the elbow, the overlapping parts being caught by the turns of bandage passing over the shoulder and round the body respectively. To prevent the internal condyle from suffering from the pressure, a large mass of gauze is applied behind the arm, extending downwards almost to the condyloid region, but not reaching quite so far. A mass of gauze is packed in between the arm and the side and in front, filling up the angle between the arm and the thorax (fig. 33). A smaller anterior dressing is then applied,

narrower than the posterior, reaching as far forwards as the middle line or beyond it, and outwards to the upper arm, the edge of the anterior dressing passing beneath the edge of the posterior. Thus the side of the patient is completely encased in a gauze dressing. This is very easily bandaged on. One turn of bandage passes round the body outside the arm (fig. 34, 1); the second also passes round the body, but below the elbow (2), thus catching the portion of the dressing overhanging the elbow and also the lower edge of the front dressing; the next passes round the body and over the top of the shoulder on the side operated on, thus catching the portion

FIG. 34.—DRESSINGS APPLIED AFTER EXCISION OF MAMMA AND AXILLARY GLANDS TO SHOW THE ARRANGEMENT OF THE DRESSINGS AND BANDAGES.

The turns of bandage are numbered, and arrows are placed on them to show the direction in which they run.

of the dressing projecting above the shoulder (3); the bandage then passes down behind but parallel to the arm, turns round below the elbow, runs obliquely upwards in front to the top of the opposite shoulder (4), then obliquely back again behind the body (thus fixing the upper angles of the dressing in front and behind) to the middle of the arm, over which it passes obliquely downwards (5), to go under the wrist and end at the top of the shoulder (6)—in this way completing the fixing of the dressing to the arm, and at the same time acting as a sling for the hand. A bandage six yards long generally does this exactly.

Pins are now inserted at all the necessary points, more especially where the bandage passes over the shoulder and under the elbow. The arm and dressing are then fixed securely to the side by a binder of calico, broader than the length of the upper arm, passing round the body, below the axilla of the other side, and pursed up and pinned above the shoulder, and below the elbow of the included arm. Thus perfect rest is procured, and no elastic bandage is required.

When the axillary incision is soundly cicatrised, and the discharge has become small in amount, the axillary dressing or the breast dressing No. 2 may be applied, the arm being simply supported in a sling.

FIG. 35.—BINDER APPLIED OUTSIDE THE DRESSING REPRESENTED IN FIG. 34, SO AS TO KEEP THE PARTS AND DRESSING AT REST.

An *axillary* dressing must be applied partly to the chest and partly to the upper arm, and made to fold over the top of the shoulder. It requires an elastic bandage (fig. 36).

Elastic bandage is not as a rule required for *dressings on the extremities*, because the limb operated on is generally placed on a splint for a few days, in order to procure absolute rest till healing by first intention is complete. Thus the movements which it is the function of the elastic band to neutralise are avoided, and the constriction of the elastic is also avoided. With regard to this constriction, however, the

elastic need never be applied so tight as to produce œdema; indeed, I have more than once seen œdema which was present before an operation subside afterwards, even although an elastic bandage was used. Where the patient is allowed to move the extremity—as, for instance, when he is allowed to walk after a small operation on the lower extremity—an elastic bandage is absolutely necessary. In the case of the lower extremity, the padding at the upper part of the splint should be covered with

FIG. 36.—DRESSING IN CASES OF OPERATION ON THE AXILLA ALONE.

In this case an abscess has been opened and the position of the drainage-tube is indicated by dotted lines. The edge of the dressing has also been dotted in.

macintosh, and the foot of the bed supported on blocks. In this way all the discharge flows upwards, and as it cannot soak into the padding of the splint, it is shed on the drawsheet soon after it has reached the edge of the dressing, and thus one can ascertain accurately whether or not it is necessary to change the dressings.

The dressing required for *psoas abscess* opened above Poupart's

ligament is one of the most important dressings, as well as one of the simplest illustrations of the method of applying the elastic bandage. I may say here with regard to this method of opening psoas abscess above Poupart's ligament, that there are two reasons for choosing this situation. In the first place, the old rule that these abscesses must not be opened early is now done away with, and under truly aseptic treatment, as soon as fluctuation is detected, an operation is performed of a similar nature to that for tying the external iliac artery, and the abscess is opened after a careful dissection. The sooner the

FIG. 37.—DRESSING IN A CASE OF PSOAS ABSCESS OPENED ABOVE POUPART'S LIGAMENT, SEEN FROM THE FRONT.

The position of the drainage-tube is indicated by dotted lines.

abscess is opened the better, for the abscess cavity is thus smaller than if the surgeon waits till the pus has burrowed its way into the thigh; and, further, so long as the pus is there it irritates by its tension, and thus keeps up the chronic inflammation in the spine. This, then, is one reason why the opening leading into these abscesses is generally above Poupart's ligament. Another is, that even supposing the abscess to be pointing in the thigh, it ought to be opened as far as possible from sources of putrefaction, and the most convenient place in this respect, as well as the best for the attachment of a dressing, is the

neighbourhood of the anterior superior spine. Some surgeons, more especially Mr. Chiene, try to get at these abscesses from behind, either by perforating the ala of the innominate bone or by getting at the pus above the crest of the ilium. Such a method has advantages, both by providing a dependent opening and also by leaving a shorter channel between the seat of the disease and the cutaneous surface.

The dressing applied when the opening is in the neighbourhood of the anterior superior spine extends from the middle line in front to the middle line behind. It reaches as high up as the lower border of the ribs and as low as about three inches below

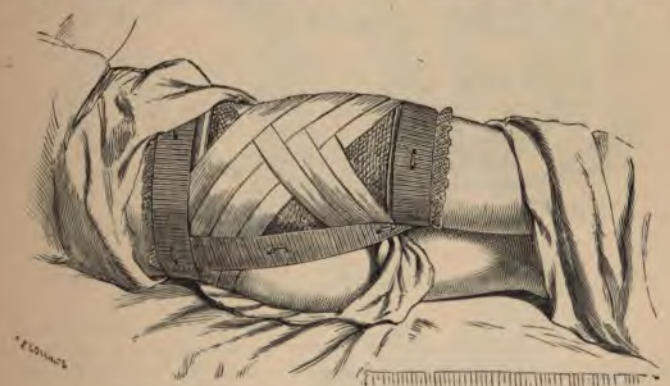


FIG. 38.—PSOAS ABSCESS DRESSING (FIG. 37), SEEN FROM BEHIND.

Poupart's ligament. Special masses of gauze are placed in the neighbourhood of the pubis, which is also shaved on that side. The dressing is fastened on by a spica bandage with circular turns around the thigh and abdomen. The elastic bandage is applied accurately to the edge. It begins, say, at the upper and anterior angle of the dressing, runs vertically downwards along the anterior edge; then, passing back round the inner side of the thigh, it encircles the thigh, thus fixing the lower border; then it runs vertically upwards behind till it reaches the upper posterior angle; then, being held there, it is carried

round the abdomen. The two ends of the two vertical pieces are fastened to the circular piece by pins, and pins are also applied at all the angles and along the edge where necessary. In some deformed persons shoulder straps are necessary to prevent the dressing from slipping down (figs. 37 and 38).

In *lumbar abscess* straps must pass over the shoulders to prevent the dressing from slipping down, and between the thighs to prevent it from slipping up (fig. 39).

FIG. 39.—DRESSING IN A CASE OF LUMBAR ABSCESS, SEEN FROM BEHIND.

The position of the drainage tube is indicated by dotted lines; the vertical dotted lines at the middle of the back indicate the edge of the dressing.

In *abscess of the hip-joint* the arrangement of the dressings is much the same as in psoas abscesses, except that they pass lower down and not quite so high up. As a long splint is generally in use, an elastic bandage is unnecessary, unless in children (fig. 40).

Where abscesses are opened near the top of the thigh on the inner side, and are thus close to sources of putrefaction, large masses of gauze must be applied between the orifice and the perineum, and an elastic bandage carefully fastened along the upper edge.

In *operations for hernia, varicocele, and on the scrotum*, in

the male, there is one form of dressing which is generally applicable. In the first place, no protective is used, on account of the immediate vicinity of sources of putrefaction, as has been

FIG. 40.—DRESSING IN A CASE OF HIP-JOINT ABSCESS, WITH ELASTIC APPLIED.
The dotted part shows the position of the wound.

FIG. 41.—DEEPER PART OF THE HERNIA AND SCROTAL DRESSINGS.
Left side of scrotum covered with gauze soaked in carbolised glycerine. Mass of gauze in the perineum enclosed in a roll of gauze.

previously explained. The gauze applied to the wound, instead of being merely wet with carbolic lotion, is steeped in 1–5 or in

1–10 solution of carbolic acid in glycerine, and this is wrapped around the penis and over the scrotum. This gauze sticks to the skin and does not become detached with the movements of the body, while it is more powerfully antiseptic than the ordinary carbolic gauze. Then a mass of gauze is rolled into a ball, and this is suspended in the centre of a long strip of gauze. The ball is placed in the perineum behind the scrotum, and the strip of gauze passes up in each groin. This strip retains the pad in position (fig. 41). The pad serves the double purpose of supporting the scrotum and receiving the discharge, which passes chiefly downwards. The hollows having been

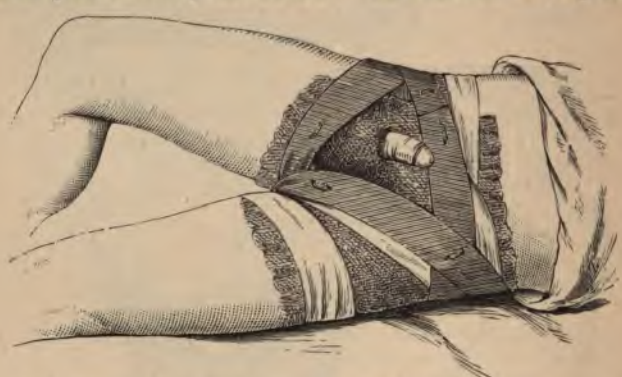


FIG. 42.—DRESSING IN A CASE OF OPERATION FOR HERNIA, OR ON THE SCROTUM ON THE LEFT SIDE, SHOWING THE ARRANGEMENT OF THE DRESSING AND ELASTIC BANDAGE.

filled up with loose gauze, the general dressing is applied. A hole is cut in this dressing towards the upper border, and the penis is passed through this hole, and thus helps to keep the dressing in position. The dressing passes over the scrotum and over the perineal pad, and is fixed by a double spica bandage (fig. 42). The pad in the perineum is fixed there by a St. Andrew's cross. The elastic bandage is applied in the form of a St. Andrew's cross in the perineum, and of a double spica (fig. 43). The bandages, dressing, and perineal pad are carefully pinned together in the perineum.

The methods of managing *excisions of joints*, operations for ununited fractures, &c., in the lower extremities, are very important. Here perfect rest must be combined as far as possible with the aseptic treatment. For two or three days after excision of the knee it is better to change the dressing, which is the ordinary gauze dressing applied round the limb, simply by lifting the limb, because there is generally a large amount of bloody and serous oozing at first. After a few days this oozing has become much diminished in amount, and the dressing

FIG. 43.—DRESSING IN HERNIA CASES OR IN OPERATIONS ON THE SCROTUM, SHOWING THE ARRANGEMENT OF THE BANDAGES IN THE PERINEUM, SEEN FROM BELOW.

is then accomplished in the following manner. A Gooch's splint is padded above and below the situation of the wound, the part opposite the wound being left unpadded. The whole splint and padding is covered with a piece of macintosh cloth, and is firmly fixed to the posterior aspect of the limb above and below the situation of the wound. Behind the wound, at the part where the padding is deficient, masses of gauze of sufficient thickness are arranged transversely and superficial to the macintosh. These pieces are three or four or more in number, and they act as padding for the splint, and at the same

time as an antiseptic dressing (fig. 44). When the dressing is changed, a piece of gauze is pinned to each of the old pieces, and then the old piece being pulled out the new is pulled in,

FIG. 44.—SPLINT FOR EXCISION OF KNEE, READY FOR APPLICATION.

The splint is padded at the upper and lower parts, and the splint and padding are covered with a piece of macintosh cloth. The space opposite the knee is filled with masses of gauze arranged transversely and superficial to the macintosh.

and thus the limb is never left without support (fig. 45). Over the front of the limb an ordinary gauze dressing of suitable size is applied.

FIG. 45.—SPLINT APPLIED IN A CASE OF EXCISION OF THE KNEE.

This shows the method of changing the dressing. In the first way described a mass of gauze would be pinned on to the end of the old piece on the other side of the limb, so that as the old piece is pulled out the new is pulled in, or it may be arranged in the second manner described, and shown in fig. 44—viz., a piece only extends to the middle line behind, and as soon as each is pulled out a fresh piece is pushed in.

Another more convenient way in which this may be managed with even less movement is to have each of the masses of gauze mentioned in the former paragraph divided in

the middle line, and thus the half of each mass is pulled out at a time and a new piece substituted (fig. 44).

In other cases an iron rod bent up over the wound may be fixed to the front of the limb by plaster of Paris. The limb is then easily lifted out of the splint by one assistant keeping the leg and the plaster in contact, and another lifting the thigh and plaster. In this way the whole of the posterior surface of the limb is left free for the application of a large dressing, and the aseptic arrangements are more easily managed.

Another way is to apply a wire splint next the skin, fix it there, and then apply the dressings outside.

When the discharge becomes still less the limb may be put up in plaster of Paris, a window being left for dressing.

Excision of joints for disease is now, however, rarely performed, for with aseptic treatment an incision into a joint and the insertion of a drainage-tube is generally sufficient, in cases where formerly excision or even amputation would have been required. Several advantages are thus gained, among the most prominent of these being absence of shortening of the limb (and this is most important in children), and often a certain and even a considerable amount of motion in the joint afterwards.

It may be mentioned here that Mr. Knowsley Thornton in *ovariotomy* cases does not apply a bandage round the abdomen. He fastens the dressing with adhesive plaster, and does not change it for a week, by which time healing is generally complete, except where the stitches are.

Such are the chief points as to the application of antiseptic dressings in different situations. I must now say a few words as to the aseptic treatment of abscesses.

I have already referred to the question of the necessity for a dependent opening, and I pointed out that, as the discharge from an abscess treated aseptically is apparently but little irritating, it does little harm even though left to well out, instead of being permitted to flow out through a dependent opening. In fact, aseptic surgery has altered the relative im-

portance of the questions to be considered in selecting a situation for opening an abscess; and now the chief point to be looked at is not whether the orifice of the tube is in the most dependent position possible, but whether it is at the point furthest removed from sources of putrefaction—*i.e.* whether there is the greatest possible space for the overlapping of the antiseptic dressings.

Indeed, in some abscesses pointing near such canals as the pharynx, anus, &c., it is better to make an opening in healthy structures at some distance from the abscess, and burrow a channel into it, than to make an incision directly into the abscess cavity.

I saw a striking example of this in Edinburgh several years ago. A boy was admitted into the infirmary with retropharyngeal abscess connected with occipito-atloidean disease. The abscess was on the point of bursting into the pharynx. Mr. John Chiene, who had charge of the case, instead of opening the abscess at the only place where it was pointing, viz., in the pharynx, cut down behind the sterno-mastoid, and burrowed into the abscess cavity from behind. The abscess followed a typical aseptic course, and the patient recovered completely. I have also had a similar case which healed up in a few weeks without any trouble. Thus then the great rule in selecting a situation for opening abscesses is to make the incision as far as possible from sources of putrefaction.

When opened, instead of dealing tenderly with the pyogenic membrane, as was formerly done under the impression that it was a hurtful thing to injure it, we now empty the cavity thoroughly, especially in the case of chronic abscesses, in order to get out all curdy masses of pus, &c., which may have gravitated to the bottom of the abscess, and in some cases we scrape out the pyogenic membrane with a sharp spoon. When this is done opportunity is given for the rapid adhesion of the greater part of the wall of the abscess cavity, and thus in a very short time there is merely a sinus left leading down to the seat of disease.

There is no necessity for washing out the cavity of an

abscess, as is done in so many quarters. To do so is simply to irritate the pyogenic membrane unnecessarily without securing any corresponding benefit. Indeed, it might give rise to such an amount of oozing from the wall of the abscess as would wash out all the carbolic acid from the dressings in a very short time, and thus lead to the putrefaction of the discharge. The treatment by hyperdistension, while erroneous in theory, is very dangerous in practice, as the fluid may be forced into the cellular tissue, and lead to diffuse inflammation and even gangrene, or to carbolic acid poisoning and death.

The greatest care must be taken in the drainage of abscesses. In the case of a large psoas abscess the surgeon should introduce the largest sized drainage-tube in the first instance. This tube may be changed for a smaller in a few days. It ought not to be removed for the first time till at least three days have elapsed since the abscess was opened, otherwise there may be great difficulty in replacing it. It should not be shortened till it is found to be absolutely impossible to get it in fully. Whenever this is the case a piece must be cut off from the end. (Here I speak of chronic abscesses; an acute abscess heals in a week or ten days.) In some cases. where the same tube is left in for a week (where the case is only dressed once a week), some difficulty will be found in withdrawing it, owing to the granulations having grown in at the holes and holding it in position. In this instance the guide as to shortening is lost, because the tube cannot be pushed out; and therefore it will be found best in old cases to use a tube having holes only close to its inner end. This cannot be held, and is gradually pushed out as the sinus heals from the bottom. If on removal of a tube the discharge is found to increase in quantity, the tube must be reintroduced.

As the incision into the abscess is merely large enough to admit the tube, there would be no reason for using protective; and therefore the wet gauze is applied directly over the orifice of the tube. A tube is the only form of drain suitable in these cases.

The precautions required in order to insure an aseptic result are precisely the same as in the case of wounds.

In changing the dressings the same rules are followed as were formerly described with regard to incised wounds. Chronic abscesses, more especially abscesses connected with diseased bones, are extremely tedious; but nevertheless, as a rule, they ultimately recover. The same care must, however, be taken from first to last. It is never safe to change the carbolic dressing for a boracic one, however superficial the wound appears to be. In the case of spinal abscesses absolute rest in the recumbent posture must be maintained till healing is complete; and as the cases generally extend over many months, it is well to warn patient and friends before commencing to treat the case. Whether the rule as to the maintenance of the recumbent posture may not be modified by the use of Sayre's jacket, or even without it, is now a question. Lately in two cases which had been under treatment for a long time, and in which all uneasiness in the spine had passed off, Sir Joseph Lister allowed the patients to get up before healing was complete, and no harm followed.

Empyema does particularly well under this dressing. I mention it, in order to state that a metallic drainage tube with a shield like a tracheotomy tube, and with lateral holes, is the best, because the india-rubber tube may get compressed between the ribs or be too abruptly bent where it passes into the interior of the pleural cavity.

There are some cases in which neither the gauze dressing nor the boracic can be employed, but which may nevertheless be treated aseptically. I refer especially to abscess in the perineum or by the side of the anus.

Abscess in the perineum may be treated aseptically with very satisfactory results. The abscess is opened under the spray, and a piece of lint dipped in 1–5 carbolic oil or 1–10 carbolic glycerine is introduced into the cavity to act as a drain. Outside this two or three layers of lint soaked in 1–5 carbolic oil or 1–10 carbolic glycerine are applied, and fixed with a

T-bandage. Should this become displaced or wet with urine, &c., the patient pours a little carbolic oil or glycerine over the wound and over the lint, and replaces the dressing. No spray is required in changing the dressings. On the third day a piece of lint dipped in carbolic oil is laid over the wound, and a pair of oiled forceps is slipped under the lint to seize and withdraw the plug; or the plug may simply be pulled out under the spray. Carbolic oil or glycerine 1–10 is then used for dressing, and when the wound has become superficial boracic or salicylic ointment is employed.

The same method of dressing is employed in abscesses beside the anus. In this case, when the patient defæcates, he holds aside the dressing, defæcates past it, wipes the parts with 1–20 carbolic lotion and then with 1–10 carbolic oil. He then soaks the dressing with the oil, or applies a new dressing. (The glycerine and carbolic acid may also be used.) The result of this method of treating these abscesses is often excellent, fistula in ano being apparently often avoided when the abscess is taken in time.

So much for wounds made by the surgeon and their treatment. I now come to the consideration of *wounds produced accidentally*. Here the problem is different from and much more difficult than the former. In the cases we have just been considering we had merely to keep out the septic particles; in the present instance these particles have already gained admission, and therefore we have not only to prevent the entrance of more, but also to destroy those already present.

This is done by washing out the wound with 1–20 carbolic lotion, provided it be recent, *i.e.*, made within twenty-four hours, and then treating it like a wound made by a surgeon.

This washing out of the wound must be done very thoroughly. It is best carried out by using a syringe with a gum-elastic catheter attached to it. The point of the catheter is introduced into all the recesses of the wound and the 1–20 lotion is

injected through it, and thus comes thoroughly in contact with all parts. There must be no attempt to distend the cavity, as, for instance, by shutting the orifice of the wound around the syringe, for the fluid might be forced into the cellular tissue and lead to inflammation or even sloughing. The opening must be left perfectly free, and enlarged if necessary. Should there be any shreds of tissue, they had better be cut off, and if there be much dirt ground into the tissue, it must be got rid of by means of a nail brush. The injection and the subsequent procedures are carried out under the spray.

If the wound was made twenty-four to forty-eight hours before being seen, a stronger solution is employed, viz., the 1–5 spirituous solution. This is used in the same way as the other.

Having thus got the wound pure the question of stitching it up arises. The answer to this question varies according to the parts injured. As a rule, in injury of the soft parts, a drain is introduced, and the same accurate stitching employed under the spray as was described on a former page. More especially is this the rule in scalp wounds, where most brilliant results may be obtained by the use of catgut drains and accurate stitching. The rest of the treatment is the same as in operation wounds.

Where the wound is much contused, the same rules apply as to purification, but it must not be stitched up. After purification a drainage-tube is inserted if necessary, the wound is left open, a piece of protective is placed over it, and the dressing applied in the usual manner.

I have mentioned the methods to be employed when the wound is seen within the first forty-eight hours. It may be, however, that it does not come under notice till putrefaction already exists. In this case it may be purified by the introduction of iodoform suspended in water by the aid of alcohol, or if superficial, by stuffing it thoroughly with lint dipped in 1–5 carbolic oil. This dressing repeated for several days generally converts it into an aseptic wound. In most cases it is best to apply iodoform or the chloride of zinc solution.

Certain special wounds call for attention.

Compound fractures are the wounds in which aseptic treatment was first applied, and in which excellent results can be obtained. There are a few special points to be noted. In purifying the wounds great pains must be taken. Any dirt must be carefully scraped or scrubbed out. All blood-clots ought to be turned out as completely as possible. The ends of the bones are cleaned, and if they cannot be returned or got to fit, portions should be sawn off. The ends may be tied together with silver wire. The parts ought to be well kneaded as the carbolic lotion is injected through the catheter, in order to diffuse the lotion as much as possible into all the recesses of the wound. No stitches are inserted, but, on the contrary, free drainage by tubes is used. The same sort of dressings and apparatus are employed as in excisions.

Wounds involving tendons, nerves, or muscles, are treated in the same manner as other wounds, and the ends of the divided muscles, tendons, or nerves, ought to be stitched together with catgut, and the position of the part so arranged as to avoid dragging on these stitches.

Wounds of joints are very important. When recent no operation (excision or amputation) is required in the first instance. As a rule the joint may be saved, and perfect movement obtained by washing it out very thoroughly with carbolic lotion 1–20. The wound in the joint is enlarged if necessary. Where several hours have elapsed since the accident (more than eight or ten hours), it is well to employ the spirituous solution as well as the watery. A drainage-tube is introduced into the joint, but no stitches are used. After a few days, when the discharge has diminished, the drain is removed. In about three weeks, or earlier, passive motion ought to be begun, otherwise the adhesions outside the joint may become so strong as to require to be broken down under chloroform.

Compound fractures of the skull are treated in the same manner as compound fractures elsewhere, purification being attempted with 1–20 carbolic lotion. The dura mater may

be freely dealt with without fear of inflammation, for the irritation of carbolic acid is only very transient. Bleeding vessels are secured by catgut. Should one of the great sinuses be wounded, a graduated compress of catgut arrests the hæmorrhage satisfactorily. This I have known to act very well in a case of wound of the longitudinal sinus, occurring during the operation of trephining over the seat of an old injury.

Wounds penetrating the thoracic cavity are much more difficult to treat. Should the wound penetrate the lung, and should the lung protrude, the exposed parts and those around are purified with carbolic lotion 1–20. In deciding as to returning the injured lung and stitching up the wound, the surgeon must be guided by the circumstances of the particular injury. In some cases, if the wound in the lung were superficial, the edges of the divided visceral pleura might be stitched together with fine catgut, the lung returned, and the external wound closed. Where a large bronchus is injured it might be better practice to leave the lung in the wound, and leave the wound open.

Where there is merely a wound of the parietal pleura, and where the lung is not wounded, the external wound only is purified and is closely stitched, in the hope that union by first intention may occur, that the air may be absorbed, and that any septic dust present in the pleural cavity may be unable to cause mischief.

Wounds of the abdomen are variously treated, according as there is or is not protrusion of the contents. Where there is no protrusion, and where there is no reason to suspect injury of the viscera, the external wound ought to be purified and closely stitched, so as to get primary union throughout, no drain being used.

Where the intestines protrude, they ought to be carefully bathed in warm carbolic lotion 1–30 or even 1–20, and if there be no injury of them in any part they may be returned. If they are cut, the gut may be stitched with catgut by the glover's suture.

If the omentum protrudes, opinions vary as to the treatment. When it can be returned, do so after thorough purification, and then stitch the abdominal walls, including the peritoneum, close together. Where, from adhesion or other sufficient cause, this cannot be done, or where the omentum is very dirty, I should, from a research into the consequences of unreturned omentum by Dr. Kenneth McLeod, of Calcutta, consider it the safest practice, especially in the case of a person with strong muscular parietes, to stitch the deepest parts of the omentum to the deep part of the wound, cut off the remainder and close the skin over all.

If internal hæmorrhage is going on, apparently from the mesenteric vessels, the wound may be enlarged and the bleeding point sought for. Simon advised that in bleeding from ruptured kidney, the injured organ should be excised; this suggestion was never put into practice, but nevertheless it is one well worth bearing in mind.

Such are the chief points to be attended to in recent wounds; there remains for consideration the class of cases in which putrefaction has been present for a long time. I refer to cases of putrid sinuses, generally connected with diseased bones or joints. An attempt may be made to purify these during the course of an operation, and sometimes when the sinuses are few and uncomplicated, and where all the dead bone is removed, this attempt may be successful. The sinus is scraped out with one of Volkmann's sharp spoons (fig. 46), and all the granulation tissue, as far as possible, removed. The raw surface of the sinus, &c., is then washed out with the chloride of zinc solution, which is applied thoroughly to all parts, and a gauze dressing is used, in the hope that putrefaction has been thus eradicated. The spray should be employed during the whole procedure.

If this is successful, well and good. If not, boracic ointment (at first full strength, afterwards half) or salicylic ointment, covered with boracic lint or salicylic wool, is the best dressing,

ndeed, it is the best dressing in all cases where strict aseptic measures are inapplicable.

The aseptic treatment of burns varies according to the degree and extent of the injury. In any case, unless where the burn is very extensive and where the parts are extremely dirty (necessitating scrubbing of the surface and consequent shock and also risk of carbolic poisoning), an attempt should be made to purify the surface with 1–20 carbolic lotion. This having been done, if the surface is small, boracic ointment (full strength)

FIG. 46.—TWO FORMS OF SHARP SPOONS, A LARGE ROUND ONE AND A SMALL OVAL ONE.

and boracic lint form a convenient dressing. When the extent of the burn is greater, wet boracic dressing (wet boracic lint used as water dressing—covered by gutta-percha tissue or macintosh) is the most suitable. The wet boracic dressing is also applied in those cases where, on account of the extent of the burnt surface and the amount of dirt, purification with carbolic acid is not advisable. Where the surface is thoroughly charred and where the wound is not very extensive, boracic ointment or carbolic oil 1–10 are the best dressings. The objection to carbolic oil, which was formerly used in all cases, is that, when the surface is large, there may be a fatal absorption of carbolic acid.

In the after-treatment the sores are dressed with boracic dressings (protective and boracic lint, or better, in the first instance, boracic ointment), just as in the case of ulcers.

The rules as to the treatment of gangrene are altered in aseptic surgery, and this is more especially the case with senile

gangrene. Should symptoms of senile gangrene set in, say in the lower extremity, the skin of the foot, toes, and leg are thoroughly cleansed with 1–20 carbolic lotion. This must be done very efficiently. All the folds about the nails, &c., must be carefully cleansed and washed. This having been done, the whole limb and foot are enveloped in a large mass of carbolised cotton wool (carbolised in a 1 per cent. ethereal solution of carbolic acid). This being pure in its substance, and being applied over a pure surface, completely shuts out causes of putrefaction. The carbolic acid soon flies off, and then the cotton wool acts simply as a filter while it protects the part from unequal pressure and retains the heat. This may be kept on for any length of time, and so long as discharge does not extend to the surface or the gangrene spread above the limits of the dressing, the part remains sweet, and very often the gangrene, which in the first instance threatened to involve the whole leg, becomes limited, and there may even be merely a small cutaneous slough. In any case, as a rule, the gangrene does not go on spreading as it does when treated in the usual manner, and for this reason: Suppose that the part is not treated aseptically, the tissue at the edge of the dried gangrenous mass becomes putrid, the living tissue in the neighbourhood is very weak, the putrid material acts on it like a caustic, destroys its vitality or excites an inflammation which kills it, and so the gangrene goes on spreading, till at length parts are met with of sufficient vitality to resist this action of the putrid materials. Then a line of demarcation is formed. On the other hand, when the gangrenous parts are not putrid, the weak parts in the vicinity, which would to a certainty have died in the former case, retain their vitality and gain strength. Thus also the rule of never amputating in senile gangrene, except to trim a stump formed naturally, is done away with, and it is generally better to amputate as soon as it is clear to what extent the tissue is dead, rather than to subject the patient to the continual pain and irritation arising from the presence of the dead piece. The same reasoning applies to cases of traumatic spreading gangrene. This is

only one instance of how completely many current ideas as to surgical pathology and treatment are reversed, when means are taken to render the dust of the atmosphere inert before it reaches a wound.

In treating nævi great benefit is obtained from the injection of pure carbolic acid. The nævus is first thoroughly cut off from the circulation by ligatures tightly applied around its base, and then half minims of pure carbolic acid are injected into various parts of the tumour. Ten minutes or so having been allowed to pass, in order to insure complete and firm coagulation, the ligatures are divided and removed, and the punctures are touched with collodion. The surface being left completely dry, any slough which forms becomes absorbed or separates as a crust after some time, the part beneath being found to be a scar.

The same method has been employed in the treatment of varicose veins. A tourniquet having been firmly applied around the upper part of the limb in order to arrest the circulation, the vein is punctured at various parts, and half minims of carbolic acid are introduced into it. The tourniquet is kept on for ten minutes after the injection is completed. Coagulation and a slight degree of inflammation are thus induced, but this, so far as I have seen, never goes to any dangerous extent, and is followed by at least temporary cure.

A dissection or post-mortem wound does not, as a rule, give rise to bad results if the wound be instantly purified with 1–20 carbolic lotion. In many cases the organisms introduced are non-spore-bearing, and are thus very readily destroyed by the solution. Even anthrax does not produce spores in the living body, and thus the bacilli are rapidly killed by the carbolic lotion.

CHAPTER VII.

ASEPTIC SURGERY—MODIFICATIONS.

Country practice: *How to dispense with the spray during the operation—and during the after-treatment*: *How to render the dressings less frequent*: Is the aseptic method applicable in war? *Sir Joseph Lister's suggestions*: *Esmarch's plan*: *Reyher's method.*

Such are the methods usually employed in carrying out the Listerian principle in hospital or in private practice. It is, however, said to be difficult of application to country practice, and we must therefore inquire in what way it can be made easier. The difficulties urged are that the spray is too heavy to carry: that it is not always easy to return a long distance to see a patient on the day after the operation, and that the dressings are too expensive for the lower classes. We must therefore, in some way or other, render the dressings very infrequent, so as to avoid expense and unnecessary visits, and we must try to dispense with the spray.

In the first instance, in going to perform an operation or to treat a wound the surgeon takes instruments with him, and he may, without any additional trouble, easily add a spray to the contents of his bag, and this spray may be left at the patient's house, and brought home again after the first dressing. But, suppose the surgeon has not a spray at hand. What is to be done? Well, he must use all the other precautions before described, and wash out the wound frequently with 1–40 carbolic acid lotion during the operation, and while the stitches are being inserted; and then, before the piece of wet gauze is applied, he may distend the wound with the same lotion, the

wet gauze being applied while this is still flowing out. At the same time I cannot see that, in the great majority of cases, it can be any great hardship to carry a spray to an operation.

During the after-treatment a spray is not necessary. The spray may be rendered unnecessary during the after-treatment in two ways. In the case where catgut stitches and catgut drains are used a deep dressing may be applied at the time of the operation, and may never require to be changed. This deep dressing is fixed down in some way or other, and is treated as a wound, the gauze being soaked with carbolic lotion every time the superficial dressing is removed, and then a piece of wet gauze larger than the deep dressing, and the general dressing are applied. Should it be necessary to remove the deep dressing, there is no necessity for the spray, if catgut drains be used, because there is no cavity into which air may pass. The deep dressing having been removed, carbolic lotion is allowed to flow over the wound till a guard is applied. Where a tube is used it is more difficult to do without the spray, for in that case there is an open orifice into which dust may fall, and be sucked into the interior of the wound, and further, when the tube is removed, air must enter to take its place. This may be avoided by the use of a syringe which constantly keeps a stream of carbolic acid lotion passing over the wound and over the drainage tube, till a fresh dressing is applied. Should it be necessary to remove the tube it is well, in addition to this constant flow of lotion, to cover the orifice of the tube with a rag dipped in the antiseptic lotion. The best way is to take a guard soaked in carbolic lotion and folded in several layers, and place this over the orifice of the drainage-tube, extending on each side of it for a considerable distance. The tube is now seized with a pair of forceps through this rag, and as it is pulled out the rag is carefully tucked in around it, so as to compel the air, as it passes in to take the place of the drainage tube, to traverse the moist guard. This seems to me better than the method of slipping in forceps under the guard and pulling out the tube, the guard being well

pressed down on it. In taking out wire or silk stitches, the guard is pulled aside so as to expose the stitch, a little carbolic lotion is then dropped over the suture, and as the latter is withdrawn, a few drops of the lotion are applied to the orifice of the puncture.

These methods—the use of catgut stitches and catgut drain, and the employment of a permanent deep dressing, together with the hints in cases where a drainage tube or non-absorbable stitches are employed—suffice to render the operator independent of a spray.

Can we now render the dressings less frequent? This may of course be done to a certain extent by applying a larger amount of gauze, but one of the best ways is to use sponges in the interior of the dressing for the purpose of absorbing and retaining the fluid. The deep dressing having been applied and fixed, a large sponge or several small ones are placed outside it, these sponges having just been wrung out of carbolic lotion; outside the sponges and extending well beyond them is a piece of wet gauze, and then the masses of loose gauze and general gauze dressing. In this way the discharge is retained in the interior of the dressing, and of course so long as it is there, and so long as the discharge has not reached the edge of the dressing, it is as safe from putrefaction as if it were in a pure flask. By the use of these sponges several days may be allowed to elapse, in many cases, before the first dressing is changed, though it is well in every case to change the first dressing on the day after the operation. When the dressing is changed these sponges are squeezed thoroughly, washed in carbolic lotion 1–40, and reapplied. By the use of sponges two or three dressings suffice for the treatment of most operation wounds.

By the use of salicylic jute in large masses, the same avoidance of frequent dressings may be obtained, but this material is not very trustworthy as an antiseptic. If it is used it is best to place no macintosh outside it. In this way the discharge dries up beneath the dressing, and we have a combination of

dry and antiseptic dressings. I have often, after osteotomies where the wound was left open and no drainage-tube inserted, applied a large mass of salicylic cotton and left it unchanged for weeks, till in fact the wound had quite healed. Of course if the wound becomes painful the dressing must be removed and the cause of the pain investigated. I would not use the wool in cases of large chronic abscesses, such as psoas abscess, nor do I think it good if suppuration occurs in a recent wound.

By the means described, the difficulties in the way of the adoption of this system in country practice may be overcome, and instead of causing additional expense to a poor patient, it saves expense in many ways. The dressings required are so few that the price of the materials employed is not greater than that which would be necessary even if water dressing were used; and expense is saved in many other ways, notably in the rapid healing, which is of course of the greatest consequence to the bread winner.

Is the Aseptic method applicable in War?

In the 'British Medical Journal' for September 3, 1870, Sir J. Lister describes a method for the use of army surgeons. He suggests that the wound should, as soon as possible after the injury, be thoroughly washed out with 1-20 carbolic lotion, the surrounding skin being at the same time purified. Bleeding vessels are secured by catgut, by torsion, or by carbolised silk. While the wound is full of lotion, extract the bullet, clothes, &c. Then cover the wound with two or three layers of oiled silk, smeared on both sides with carbolic oil 1–5. Over this apply layers of lint soaked in the 1–5 oil, overlapping the oiled silk for about three inches in every direction, and about a quarter of an inch in thickness. This is covered with gutta-percha tissue, and the whole is fastened on with a bandage soaked in carbolic oil. This is the permanent dressing. Outside this, another and larger dressing of oiled lint covered by gutta-percha tissue is applied daily. During the first day apply fresh oil to the outer cloth once in six or twelve hours. On

the following day the outer dressing is changed, carbolic lotion being introduced under the edge, as it is lifted, by means of a syringe; or carbolic oil may be poured in. After the first dressing use the 1–10 oily solution, and later the 1–20. On the second day oil is only applied once in twelve hours; after that it is applied daily for five or six days, and then once in two days.

In compound fractures use a wire splint next the deep dressing, and apply the fresh superficial dressings outside the wire. This splint need not be removed till union is complete, the oil being merely poured between the meshes when the dressing is changed.

Since the introduction of corrosive sublimate into surgical practice, methods are being devised for applying it in war. These methods are as yet incomplete, and have not been practically tested, but there can be no doubt that it will prove to be one of the best and most easily used antiseptics for the purpose.

Esmarch, in Langenbeck's 'Archiv,' vol. xx. p. 171, proposes another plan of treatment.

He points out that the new form of bullets passing quickly through the clothes may not carry into the wound any causes of putrefaction, or if any pass in with the bullet they may also be carried out by it. Therefore, if the wound is not examined by dirty fingers or instruments, and if it be seen at once, it may in most cases be regarded as aseptic. Starting on this principle, he suggests that each soldier should be provided with tampons of salicylic cotton, wrapped in salicylic gauze. Fig. 47 represents the contents of the packet of dressings which Esmarch proposes to supply to each soldier. At the front, when there seems any possibility of saving the limb, these tampons are introduced into the openings, and bandaged on without preliminary probing or examination of the wound. Any other necessary apparatus is applied, and the patient sent to the rear. At the rear the skin around the orifice is purified with some antiseptic lotion, and if there is any necessity to

FIG. 47 (FROM MACCORMAC).

Esmarch's first dressing for the wounded in battle. 1. Packet folded up. 2. Triangular bandage. 3. Gauze bandage. 4. Antiseptic tampon. 5. Tampon and square of oiled paper.

explore the wound, as for removing bullets, splinters, &c., the tampon is removed under the spray, the wound washed out, and an antiseptic dressing applied. If there is no necessity for exploring the wound, the skin is merely purified, and then a mass of salicylic jute or other antiseptic material is applied without disturbing the tampon. If putrefaction occurs later the wound must be enlarged, and an attempt made to purify it.

Conservative surgery being more applicable with the aseptic method, the necessity for primary amputation at the front is less frequent. and as a rule exists only in the case of smashes from large balls. Esmarch considers that for such cases a sufficient supply of antiseptic materials should be present in the ambulance. Referring to those cases not treated aseptically which do well, and to the evils of investigating the wound at the first, Esmarch says: 'So far as I can learn, those cases which followed an aseptic course were not examined with the finger on the field of battle, but were dressed at once, while those cases in which repeated examinations were made appeared to me often to run a particularly unfavourable course.'

Esmarch's method has been put to the test by Dr. Reyher during the late Russo-Turkish campaign. His results were excellent. He carried out the aseptic method in two ways, according to the nature of the injury and the treatment before the case came into the surgeon's hands. These are, either that the surgeon closes the wound without further treatment, merely disinfecting the surrounding parts, or else that he cleans out and purifies the track of the bullet, and afterwards makes provision for free aseptic drainage. In the first instance healing occurs under a crust; in the second, under a moist and antiseptic dressing.

The cases which are suitable for the first method of treatment—treatment by a crust—are those in which the wound is small, where no clothing has been carried in with the bullet, where the edges of the wound fall together, as where the wound is more or less valvular, and where no examination of the

wound by finger, probe, &c., has been made. In such a case the surrounding skin is carefully purified, and an attempt is made to obtain a dry crust, either by allowing the blood to dry, or by aiding the drying by applying charpie, gauze, &c.; or the wound may be covered by a mass of salicylic wool or carbolic gauze. Reyher lays particular stress on the avoidance of probing or draining such wounds. On the contrary, any communication with the outer world should be shut off as soon as possible.

In many cases this 'occlusion' of the wound cannot be depended on, and the bullet track must be washed out, and treated in the way described under compound fracture, free drainage being carefully provided. This is chiefly the case where the missile has been travelling slowly, and where, consequently, the wound in the skin is not so small nor valvular, and where there is more likelihood of articles of dress being carried in with it; where, also, as Reyher puts it, the wound is open and 'the air has not only entered but must enter again.' This treatment is also necessary in cases where wounds have been examined with unclean fingers or instruments before reaching the ambulance.

It is thus evident that the spray is not required for the majority of cases, and indeed by following the lines previously indicated it may be entirely dispensed with. The gauze required for the dressings can be made in the vicinity, and for this purpose Reyher carried with him the machine for making gauze described in 'Antiseptic Surgery,' Chapter III., and had thus a constant supply of the freshly-prepared material. There is not much difficulty, therefore, with regard to the materials; the real question is how to have the cases treated aseptically from the very first. Reyher was able to overcome these difficulties by proceeding in the following manner. In the first place, instructions were given that wounds were never to be examined at the front, either with fingers or instruments, nor was any attempt to be made to extract a bullet. The only exceptions to these rules were cases where blood-vessels were

injured, though even in these it was generally possible to apply an Esmarch's elastic band to control the hæmorrhage temporarily; and cases where the projectile had passed into the large cavities of the body, and, without wounding the contents, had remained in the wall of the cavity. In such a case the bullet ought to be extracted at once, lest it should fall into the cavity during the transit of the patient. 'For surgeons at the front there is only one line of treatment—to occlude the wound provisionally, to lay the wounded part in a suitable position on the litter, and to render it provisionally immovable. As provisional dressing the salicylic balls recommended by Esmarch are the best.' This method is chiefly suitable for cases where the soft parts alone are injured. Most of the serious cases can be attended to as a rule at the foremost ambulance.

The more surgeons become imbued with the true principles of aseptic surgery, and the more thoroughly they grasp antiseptic surgery in all its developments, so much the greater is the likelihood of obtaining aseptic results. Reyher's results show strikingly what can be done with the methods at present at our disposal. There can be no doubt that with improved methods and increased knowledge and experience, aseptic surgery will soon be universally carried out in war.[1]

[1] For a *résumé* of the opinions of army surgeons on the best method of carrying out aseptic surgery in war, see a little pamphlet by Surgeon-Major H. Melladew, *Notes on Antiseptic Surgery in War*. London: Ranken & Co. 1881.

CHAPTER VIII.

ASEPTIC SURGERY—(*concluded*).

Other methods of carrying out aseptic surgery. Substitutes for carbolic acid: *Salicylic acid*: *Neuber's permanent dressings*: *Thymol*: *Acetate of Alumina*: *Eucalyptus oil*: *Bichloride of mercury*: *Naphthalin*: *Iodoform*: Aseptic surgery by filtration of the air. Subcutaneous surgery.

THESE are the essential details of aseptic surgery as introduced and practised by Sir Joseph Lister. The disadvantages arising from the irritating and poisonous qualities of carbolic acid have led some to seek other antiseptics as substitutes for carbolic acid. These attempts have not as yet, however, succeeded in producing any substance possessing so many advantages as that acid. The most successful substitute up till quite recently was salicylic acid, which is used on exactly the same principles, but not with the same constant aseptic results.

The use of *salicylic acid* was first advocated by Professor Thiersch, of Leipzig, and the following is a short abstract of his method of using it.

Salicylic acid is chemically nearly related to carbolic acid. Its formula is $C_7H_6O_3$, differing therefore from that of carbolic acid in containing in addition the atoms of carbonic anhydride. (The formula of carbolic acid is C_6H_6O.) Salicylic acid is not poisonous, but it affects the hands in the same way as carbolic acid. It is absorbed, and may be found in the urine of patients whose wounds are dressed with it.

A lotion of salicylic acid is employed. This is a saturated solution of the acid in water at the ordinary temperature, and

its strength is about 1 part of salicylic acid to 300 parts of water.

Two materials are used as dressings—viz., salicylic wool and salicylic jute.

Salicylic wool is cotton wool impregnated with salicylic acid in the proportions of 3 and 10 per cent. by weight.

The 3 per cent. wool is made by dissolving 750 grammes of salicylic acid in 7,500 grammes of spirit (83 sp. gr.). This solution is then diluted with 150 litres of water at the temperature of 70°–80° C.: 25 kilogrammes of pure cotton wool are saturated with this mixture.

The 10 per cent. wool is obtained by dissolving one kilogramme of salicylic acid in 10,000 grammes of spirit (83 sp. gr.), the solution being then mixed with 60 litres of water. Ten kilogrammes of pure cotton wool are soaked in this solution.

This soaking is best done in a large wooden vat, in which the layers of cotton wool have plenty of room. It is best to place only small quantities of wool (two to three kilogrammes) in this vat at a time, in order to get an equal distribution of the acid. Thin layers of cotton wool are introduced into the salicylic solution under light pressure, fresh layers being added only when the former have been thoroughly soaked. When the whole quantity has been introduced the mass is turned over, so that the undermost layer becomes the uppermost, and then it is left for about ten minutes, so as to have equable distribution of the fluid. The wool is then taken from the vat and spread out in layers. On cooling, the acid crystallises out, and the layers are made up into small parcels, not exceeding two to three kilogrammes each. After twelve hours this wool is spread out to dry in a moderately warm place. It should not be hung up, lest the acid should become unequally distributed.

The 10 per cent. wool is coloured with carmine for the sake of distinction.

It is important to note that Thiersch, in speaking of 3 per cent. and 10 per cent. wool, means wool soaked in the solutions

of the strength described. The wool does not contain that percentage of salicylic acid.

This cotton wool does not absorb fluids readily, and therefore Thiersch now uses jute. This is made from the bark of various species of Corchorus grown in Bengal, and is cheaper than cotton wool, and at the same time more absorbent. It is used of two strengths—3 and 10 per cent. prepared in the same way as the salicylic wool.

Glycerine is added to the solution in order to prevent the crystals of salicylic acid from falling out, because they are apt to produce violent sneezing, coughing, &c.

In order to obtain the 3 per cent. jute 2,500 grammes of jute are put into a solution of 75 grammes of salicylic acid in 500 grammes of glycerine and 4,500 grammes of water at 70°–80° C.

In the glycerine jute the acid is more equally distributed than in the cotton wool. In the case of the latter the cotton is frequently so imperfectly charged that it is necessary to place a layer of 10 per cent. cotton next the wound, and then outside this the 3 per cent. wool. In the case of the glycerine jute a 4 per cent. material is sufficient for the whole dressing.

As to the spray, Thiersch does not care whether it is 1–50 carbolic acid or 1–300 salicylic acid. Carbolic acid is to be preferred, because it causes less coughing and sneezing, and it does not adhere to the clothes.

Salicylic acid is best in some cases, as it irritates the wound less than the carbolic.

For disinfecting the hands and skin, carbolic acid or salicylic acid may be used, but for the instruments carbolic acid must be employed, because the steel becomes oxidised in a solution of salicylic acid.

The sponges are washed in carbolic acid.

No protective is required, because the salicylic acid is but little irritating.

Macintosh is also unnecessary.

In order to enable the dressing to peel off and to let the

discharge get away more easily, a layer of gutta-percha tissue or of oiled silk riddled with holes and covered with a piece of gauze is applied next the wound.

This treatment may be illustrated by a case of amputation.

The patient having being chloroformed and Esmarch's elastic bandage applied, the part is shaved, washed with soap and water, spirit and turpentine oil, and then with salicylic acid lotion, or with the 1–20 carbolic acid solution. It is also scrubbed with a nail-brush for a few minutes (quite unnecessary). The operation is carried out with the usual aseptic precautions. After arresting the hæmorrhage the wound is closed with deep and superficial stitches. A drainage-tube is then introduced into each angle, and the wound is washed out with salicylic acid solution till the fluid which comes out is clear (unnecessary). A piece of perforated gutta-percha tissue and three finger-breadths of carbolic gauze are then applied; over this comes one finger's thickness of the strong salicylic wool, and outside this two fingers' thickness of the weak wool. The whole is then fastened on with a bandage.

If the patient complains of pain the dressing is changed and the wound examined. If not, it is left till the eighth or tenth day, when it is changed, in order to remove the drainage-tube. If any discharge comes through in the first instance, fresh wool is put outside the dressing. The second dressing is left till healing is complete.

Large compound fractures are treated at first by irrigation with salicylic acid. In order to protect the skin from irritation, it is from time to time rubbed with salicylic cream. After all risk of abscess formation has passed off and the wound is granulating well, one may apply dry salicylic dressing as before described. As I have already pointed out, this is an excellent dressing for recent wounds but not for abscesses, nor would I use it in cases of incision into joints.

Where there is a tendency to inflammation, more especially where there is imperfect drainage with progressive abscess

formation, wet salicylic dressing should be applied. This is ordinary salicylic dressing, which is from time to time soaked with salicylic lotion.

In some cases wounds are filled up with powdered salicylic acid and salicylic wool applied outside. This is said to purify wounds already septic. In some cases, however, there is risk of salicylic acid absorption and poisoning.

In connection with the salicylic dressing, I may draw special attention to the permanent dressings advocated more especially by Neuber. For ligatures he uses catgut, for drainage absorbable tubes of decalcified bone, and in his first method he fastened layers of gauze over the wound, filled up the hollows with salicylic wool, then fastened on a mass of salicylic wool, and then outside all a carbolic gauze dressing. Such a dressing may be left till the wound heals. Later he used 10 per cent. carbolised jute wrapped in carbolic gauze. When the iodoform dressings were introduced he then used iodoform wool or jute, and of late he has employed peat mould mixed with iodoform and made up in gauze bags. This peat mould may also be impregnated with bichloride of mercury in the same way as wool (see below).

Thymol as an antiseptic application to wounds was introduced some years ago by Ranke of Halle, and was much lauded on account of its non-poisonous and non-irritating qualities.

The thymol gauze was made on the same principles as the carbolic gauze, spermaceti being, however, employed. A thymol solution of the strength of 1–1000 is made by the addition of alcohol and glycerine.

This antiseptic has not answered the expectations entertained at first. It does not prevent putrefaction, and has been justly abandoned in aseptic work.

Acetate of alumina has been lately used by Maas. He applies lint dipped in the solution ($2\frac{1}{2}$ per cent.) to the wounds, over a piece of protective, and covers this with macintosh.

The edges of the dressing are surrounded by salicylic wool. The strength of the spray is also 2½ per cent.

He says that this is a powerful antiseptic, and that with it he gets typical aseptic results. The substance is unirritating, non-poisonous, and very few dressings are required.

Eucalyptus oil has recently been strongly advocated by Dr. Schulz of Bonn.[1] Its antiseptic properties were shown by Bucholtz in his paper on Antiseptics. He found that it was three times as strong as carbolic acid, for while carbolic acid prevented putrefaction when present in the proportion of 1 in 200 parts, the eucalyptus oil only required to be present in the proportion of 1 to 666·6 parts to produce the same effect.

Siegen also showed that eucalyptus oil prevents putrefaction and alcoholic fermentation better than carbolic acid. He found that blood to which ⅓ per cent. of eucalyptus oil had been added was quite odourless ten days later. Bing states further that it hinders the passage of white corpuscles out of the vessels, and that therefore, on Cohnheim's theory, it is an agent capable of arresting suppuration.

With regard to its usefulness, its smell is more pleasant than that of carbolic acid. It dissolves readily in alcohol or in oil, and mixes perfectly with pure paraffin.

Schulz also states, from Siegen's experiments and from his own, that the eucalyptus oil is not poisonous. The tree from which the oil is obtained grows in large numbers in Australia, and the oil can be obtained in large quantities and very cheap.

Schulz recommends that for the spray the glass bottle should be filled with the pure oil or with oil dissolved in alcohol. The steam would then pick this up and make an emulsion.

As a lotion it might be used in the form of an emulsion.

Schulz proposes that the wounds should be dressed with lint saturated with a 10 per cent. solution of eucalyptus or olive oil. Outside this, or instead of it, may be used Lister's gauze dressing containing eucalyptus oil instead of carbolic acid. A gauze

[1] *Centralblatt für Chirurgie*, January 24, 1880.

which contains even 50 per cent. of eucalyptus oil may be made with paraffin. Dr. Schulz has not himself, however, used this method.

Sir Joseph Lister has for some time been making an extensive trial of eucalyptus oil in the treatment of wounds. A gauze has been prepared similar to the ordinary gauze, but containing eucalyptus oil instead of carbolic acid. Dammar has also been substituted for the ordinary resin. So far this has proved very satisfactory. It seems to be fairly trustworthy as an antiseptic, and can be used under circumstances where carbolic acid is apt to cause irritation, as in dressings on the scrotum, or in patients whose skins are liable to be irritated by carbolic acid. Being non-poisonous, it may also be substituted for carbolic acid in cases where constitutional effects are apt to follow the absorption of the latter. Indeed, of late, Sir Joseph Lister has used eucalyptus gauze almost to the exclusion of carbolic gauze. On account of the great volatility of the oil the gauze is, however, very uncertain in quality, and is, therefore, not so safe as the carbolic gauze.

It has also been employed as an ointment in the proportion of one part by measure of the oil to four parts by weight of the same base as is used for the boracic and salicylic ointments (p. 44). This ointment is employed in the cases for which boracic and salicylic ointments have up to the present been used, and it possesses the advantage over the latter in that the oil not only renders the discharge pure as it passes over it, but also, on account of its volatility, bathes the parts in an antiseptic vapour. Hence it will probably be especially useful in the treatment of burns (see p. 100). Its non-poisonous qualities are also a great point. As yet no experiments have been made with the view of substituting it for carbolic acid in the lotions used in the spray, in washing wounds, purifying instruments, &c.

Among the more recent antiseptics the *bichloride of mercury* deserves special notice. Since Koch's research on disinfection

it has been largely used in Germany. Bergmann, however, has employed it since 1878. Max Schede has done a great deal of work with it, and I will refer chiefly to his methods.

There are two solutions employed: a weak watery solution of $\frac{1}{50}$th per cent. strength, and a strong watery solution of $\frac{1}{10}$th per cent. These are used for disinfecting the skin and as lotions for the wound, &c. For the spray and the disinfection of instruments carbolic acid is still employed. The catgut is laid in the first instance for twelve hours in a 1 per cent. watery solution, and then kept in a $\frac{1}{2}$ per cent. alcoholic solution containing 10 per cent. glycerine. An antiseptic powder is formed by mixing sand which has been subjected to a high temperature with a 1 to 10 solution of bichloride in ether. A $\frac{1}{10}$th per cent. and a $\frac{1}{5}$th per cent. make a good powder for sprinkling over wounds. In the case of superficial wounds this powder is first sprinkled over them, and then a dressing of sublimate gauze or wool is applied. This dressing is made by soaking unprepared gauze or wool in the following solution: corrosive sublimate 10 parts, glycerine 500 parts, and alcohol 4,490 parts.

In the case of wounds united by stitches a layer of glass charpie is first applied, made of spun glass, which is always kept in a 1 per cent. watery solution. Over this the sand is sprinkled and then the sublimate wool, the whole being fastened by a bandage. Capillary drains of this spun glass may also be used. The dressings may be left unchanged for weeks.

Some surgeons do not use the sand loose but enclose it in disinfected bags, or instead of sand coal ashes may be used containing $\frac{1}{20}$th per cent. sublimate. The ashes are lighter than the sand.

Von Bruns employs wood wool impregnated with $\frac{1}{2}$ per cent. sublimate and 5 per cent. glycerine. He first washes the wound with the $\frac{1}{10}$th per cent. watery solution, then stitches it, uses the spun glass as a drain and covers the whole with the wood wool.

Very excellent aseptic results are obtained in this way, but sometimes severe irritation and eczema has been observed, and

also in several cases salivation. From what I know of the results I doubt if they are so constantly good as with carbolic dressings, and except in the matter of permanent aseptic dressings I do not as yet see much advantage from the use of the sublimate.

In the 'Lancet' and 'British Medical Journal' for October 1884 will be found a paper by Sir J. Lister on corrosive sublimate as a surgical dressing. He finds that if combined with serum it loses to a great extent its irritating properties. He proposes to make a gauze impregnated with a mixture of 1 part of sublimate to 100 of serum. He is, however, still working at the subject, and it is somewhat premature definitely to recommend a particular sublimate dressing.

Naphthalin ($C_{10}H_8$) obtained from coal tar has also been extensively used by E. Fischer of Strasburg. He found that while a powerful antiseptic it was not poisonous to man. Foul wounds powdered with it were soon purified.

In the case of open wounds, Fischer fills them with powdered naphthalin and then applies a mass of absorbent wool or gauze, a piece of macintosh and a bandage. The dressings are impregnated with naphthalin either by sprinkling a quantity of the powder in them, or by soaking them in a strong solution of naphthalin in alcohol and ether, and allowing the alcohol and ether to evaporate.

An ointment of equal parts of naphthalin and vaseline is also employed. Fischer also uses an ethereal solution for the disinfection of foul wounds. It is either brushed or sprayed over the surface of the wound.

In an American review of my 'Antiseptic Surgery,' I was severely blamed for not mentioning or laying stress on *iodoform* as a substitute for carbolic acid in the treatment of wounds. I omitted it intentionally, for I did not consider that it was a good antiseptic, nor did I think that it would be used for any length of time. This view has proved correct. Iodoform is

not a powerful antiseptic, and is not now nearly so much employed as it was two or three years ago. It has been found that in a considerable number of cases severe symptoms of poisoning have followed its use, while it does not even prevent the occurrence of erysipelas. In the clinique of Max Schede and others who may be trusted to observe all the necessary precautions for antiseptic work, severe epidemics of erysipelas have occurred in wounds treated by iodoform, and they have for this reason, and on account of its poisonous qualities, given up its use.

Wounds are powdered with the iodoform, a gauze or wool containing 10 to 20 per cent. of iodoform is applied, the piece of the dressing placed next the wound being, however, soaked in the 1–20 carbolic lotion. Carbolic acid is also used for disinfection of skin and instruments and for spray. There is no doubt that many good results are obtained, especially if no macintosh is applied outside the wool, but the results are not so constant as with carbolic acid, and in corrosive sublimate, salicylic acid, acetate of alumina, &c., we have much better substitutes for carbolic acid.[1]

So far we have been considering modes of preventing putrefaction in wounds, based on the fact that the septic particles in the air and on surrounding objects may be deprived of their power of causing fermentation by contact with some suitable chemical substance. But it is also sufficient for the avoidance of fermentation in flasks to keep the dust out mechanically, as, for instance, by means of cotton wool. This fact was made use of by Sir Joseph Lister some years ago in the following manner. I may quote his remarks, which are given in a foot-note to his article on Amputations in Holmes' 'Surgery,' vol. v. p. 619, published in 1871.

'Among recent contributions of fact to the elucidation of

[1] Full details with regard to the use of iodoform will be found in E. Fischer's *Handbuch der allgemeinen Verbandlehre*, Stuttgart, F. Enke, 1884.

this question (the germ theory) may be mentioned Professor Tyndall's simple but beautiful proof of the existence of organic particles of dust of excessive minuteness in the air by means of a condensed beam of light, and the equally clear ocular demonstration afforded by the same method, that even the finest particles are capable of being removed from the air by causes which Pasteur, in some of his experiments, inferred must clear it of suspended organisms, such as the action of gravity and filtration by cotton wool. The fact last named seemed to promise valuable results in antiseptic surgery, and experiments made with this view have afforded further evidence in favour of the germ theory, which it may be well to mention here. I found that if cotton wool impregnated with either chlorine or sulphurous acid gas, or with the vapour of benzine or carbolic acid, was placed upon a wound or granulating sore, after washing the surface with a solution containing the same agent, *although the volatile antiseptic left the cotton in about a day*, the blood or pus still effused beneath the cotton remained free from putrefaction for an indefinite time, provided that the discharge was not sufficiently copious to soak through the cotton and appear at the surface, in which case, the meshes between the fibres affording ample space for microscopic organisms to develop in, putrefaction spread within a few hours throughout the moistened part of the mass. This circumstance greatly interfered with the practical utility of the dressing, and it has since been superseded by the antiseptic gauze to be described in the text, but the facts seem to me important with regard to the germ theory. The cotton wool, though it loses all chemical antiseptic virtue in a day, yet will keep out putrefaction for a month or more. It cannot possibly keep out any atmospheric gas, which is necessarily diffused freely between its fibres, and gets in for the same reason that the volatile antiseptic gets out. That which it does exclude can only be suspended particles of dust. It follows, therefore, as a matter of certainty, that the cause of putrefaction through atmospheric influence of blood or pus, or, in other words, such materials as the surgeon has to

deal with in treating wounds, are not the atmospheric gases, but dust, and the fact that this dust is deprived of its putrefactive energy by agents which are chemically so unlike as chlorine, sulphurous acid, benzine, and carbolic acid, but which agree in having a common hostility to animal or vegetable life (I used benzine because I knew that the entomologist employs its vapour to kill insects), this fact confirms the view that the putrefactive particles are really organisms. I commend these simple experiments with cotton wool to the candid judgment of the reader, because, whatever may be thought of their bearing upon the allied subject of spontaneous generation, they must be allowed to afford absolute demonstration of the truth which is the foundation of the antiseptic system, viz., that the putrefaction of blood or pus under atmospheric influences is caused not by the gases of the air, but by suspended particles, which can be deprived entirely of their septic energy by the vapour of an agent like carbolic acid.'

It will thus be seen that what Sir Joseph Lister used here was not an antiseptic application but an aseptic one, and that the only mode in which this dressing acted was by mechanically preventing the particles from reaching the wound. For the reasons quoted, this method has not been turned to practical account, though, as we have seen, it is still used in cases of gangrene in order to protect the weak parts from all sources of irritation.

Mr. Barker, of University College Hospital, has tried a similar method in one or two cases. He purified cotton wool by heat, and applied between it and the wound a layer of lint dipped in carbolic oil. This method, however, seems to be impracticable, for after the wool has been heated, but before it is applied, dust would very probably gain access to it unless very complicated precautions were taken. I believe that if pure cotton wool is used Sir Joseph Lister's method is the only practicable one.

I have mentioned these experiments more as confirming the theory of aseptic work than for the purpose of recommending the method for adoption. I believe that thoroughly satisfactory,

and indeed the best, results may be obtained by the use of suitable chemical means.

Subcutaneous surgery is another way in which the aseptic principle may be carried out. Here the wound is made under the skin and away from the air dust altogether. If, however, the instruments used are not thoroughly disinfected, it may happen that micro-organisms capable of living in the tissues may be carried in with them and lead to suppuration or some other mishap.

CHAPTER IX.

ANTISEPTIC SURGERY.

Treatment by antiseptics: *Carbolic acid—objections to it: Chloride of zinc: Boracic acid: Sulphurous acid: Chlorinated soda: Alcohol—Hutchinson's method: Terebene and Sanitas—Bilguer's method—Neudörfer's salicylic powder.* Free drainage as an antiseptic method. Irrigation and immersion. Open method: *Modes in which it acts antiseptically: Bartscher and Vezin's method: Burow's method: Rose's modification.* Healing by scabbing: *Methods of forming a crust: Bouisson's ventilation method: other modes.* Guérin's cotton-wool dressing. Modes in which the destructive action of the tissues on bacteria is assisted. *Why does not fermentation always occur in the blood in wounds in which organisms are present? Best practical methods.*

I.—*Methods by which various Antiseptics are added to the Discharge, so as to hinder the Development of Organisms in it.*

WHAT are the best antiseptics to use for this purpose?

Carbolic acid is the one most frequently employed, but, in my opinion, it is by no means the best in this instance. In vegetable infusions, where carbolic acid is present in the proportions of 1–300 to 1–350, all further growth of organisms is prevented, but in such fluids as serum, milk, pus, &c., the acid forms a compound with the albumen, and a much larger proportion is required. Thus, in milk, carbolic acid in the proportion of 1–54 is just enough to prevent development. In accordance with this fact, a very strong solution would be required in the case of wounds, or it must be added in large quantities, in order to prevent the development of micro-organisms.

And so my own experience of carbolic acid as a disinfectant in the form of a 1–40 watery solution in putrid cases is unfavourable, while on the other hand, if 1–20 carbolic acid be

used, it is very irritating and interferes with healing. Injected once or twice a day, the latter destroys the superficial granulation cells, and produces a thin slough in which bacteria develop, and from which it is very difficult to dislodge them. Then its poisonous qualities are objectionable, and are of course much more evident when the acid is injected into wounds or abscess cavities than when used in the manner described in the chapters on aseptic surgery.

Further, Dr. Wilhelm Hack,[1] in a paper on the power of absorption by granulations, has demonstrated that granulations treated with carbolic acid possess many of the qualities of a recent wound as regards absorption. For instance, apomorphia which was only absorbed during the first twelve hours by wounds treated with water dressing, was readily absorbed at any time by granulating wounds treated with carbolic acid; and therefore, in the absence of information to the contrary, I should fear that some of the poisonous products of putrefaction might be absorbed with like avidity. Hence, I do not like carbolic acid unless it is used aseptically.

Chloride of zinc applied to the cut surface has been already alluded to. A single application of an $8\frac{1}{2}$ per cent. watery solution has the remarkable property of preventing putrefaction in a wound for some time after an operation; sometimes, indeed, till granulation is nearly complete. It is further useful, according to Hack's experiments, in that the slough caused by it does not permit the absorption of substances from the wound. When used in the treatment of wounds, a dilute solution (1 or 2 grs. to the ounce of water) is employed.

Boracic acid is too weak an antiseptic to be of much service as an injection, but the boracic ointment and the boracic lint act well as dressings.

One of the best antiseptic lotions is made with *Sulphurous acid.* This is a powerful germicide. It is also non-irritating and perfectly free from any poisonous qualities. It is used as

[1] *Ueber das Resorptionsvermögen granulirender Flächen*, Leipzig, 1879.

a solution which is made by mixing together equal parts of the sulphurous acid of the Pharmacopœia and water or glycerine. This may be still further diluted if necessary.

The *Chlorinated soda* solution is mentioned by Dr. Cabot as standing next to 1–20 carbolic lotion in rapidity of action on bacteria. The strength generally employed is ʒss. to ℥j of water.

Alcohol is not a bad application to wounds, but in order to be effectual it must be used strong. It has a further advantage, for Dr. Hack has shown that granulations treated with alcohol do not absorb at all or only very slightly; and to this may be attributed, to some extent, the favourable course of the cases in which wounds are simply washed out with an alcoholic solution, and a rag, dipped in the same solution, applied outside.

Mr. Jonathan Hutchinson, more especially, has had remarkably good results from the use of alcohol. His method is as follows: Having carefully arrested all hæmorrhage, chiefly by torsion, he washes out the wound with pure spirit. He then carefully arranges drainage-tubes at the most dependent parts, and stitches up the rest of the wound. Thin compresses soaked in a lotion composed of 6 parts of absolute alcohol, a half part of liquor plumbi, and 16 parts of distilled water, are now applied. These compresses are kept constantly moist, either by a nurse or by means of a drop irrigator The lint is changed daily. In the treatment of important cases, such as compound fractures and dislocations, the rule observed is never to allow the skin to become warmer than natural. His wounds generally heal by first intention, and septic poisoning is very infrequent.

In some of these cases no doubt the wound may be aseptic from first to last. To apply an antiseptic to a wound, to stitch up immediately, and then keep an antiseptic dressing constantly applied, is really to operate more or less aseptically, and I believe, with regard to Mr. Hutchinson's cases, that this partly explains the good results—the wound being aseptic, at least for a time. Then Hack's results have a strong bearing on these cases, for absorption does not take place

readily. Mr. Hutchinson is also very particular to have free drainage, which powerfully helps to maintain the aseptic condition; and lastly, he carefully selects the cases for operation, only operating, unless in cases of necessity, where the patient is in good health. This selection of cases is a thing not necessary, and not done where complete aseptic treatment is employed.

The method which I should think was the best, acting on this principle, is the following; it is practically what Sir Joseph Lister employs with excellent results, only I would reject the carbolic acid. After the wound has been made, and before any stitches are inserted, the raw surface ought to be thoroughly sponged over with chloride of zinc solution (40 grs. to the oz. of water). In the case of operations on the extremities, this is best done before the tourniquet is relaxed, so as to insure its thorough application, for otherwise the blood would wash away the solution or dilute it before it has had time to act. Silver wire stitches are then inserted—special care being taken to insure free drainage, by the use of large drainage-tubes. As a dressing in the first instance, till the bleeding has stopped, several layers of wet boracic lint (wet in boracic lotion) are applied.

On the day following the operation the lint is removed, the surface of the wound is thoroughly cleansed with acetate of alumina, sulphurous acid or chlorinated soda lotions, or with Hutchinson's lotion, and the drainage-tubes are washed out with the same, though not removed. The dressing is now a narrow strip of the salicylic, eucalyptus, or full strength boracic ointments, thinly but evenly spread on calico, and outside this, overlapping it in all directions, one or more broad layers of boracic lint or a mass of salicylic wool.

On the second or third day the drainage-tube is removed and is washed in 1–20 carbolic lotion, the wound being then syringed out with the sulphurous acid or other lotion. After a day or two the ointment over the line of incision is changed to the half-strength boracic, or if salicylic or eucalyptus ointment was used, they are retained. These dressings are changed daily at first, but when the discharge diminishes, they may be left for two days.

Terebene and *sanitas* are remarkably good applications where the smell is bad.

The results of this treatment are of course not so perfect as those of the aseptic method, for, however carefully one washes out the wound, there are pouches in it into which the fluid does not enter, and pieces of slough cannot of course be disinfected. Thus prolonged suppurations may occur, caries may continue without tendency to cure, and even accidental wound diseases (pyæmia, &c.) attack the patient.

With regard to the use of chloride of zinc, I ought to say that it is well not to apply it to wounds which must, if possible, heal by first intention, as, for instance, in incisions about the lips or face.

It was on this principle that Lemaire employed carbolic acid and coal tar; and his results, though very good, by no means correspond to those obtained by strict aseptic treatment.

It was also on this principle that good results followed the use of balsams of various kinds in olden times. The most remarkable example of the success of such attempts at rendering the wound secretions incapable of putrefaction by the use of balsams, was that of Bilguer in the last century. No doubt where the wound is shallow, and possesses few recesses, and where the balsam or other antiseptic employed fills up these recesses, we have really an aseptic treatment and an aseptic result.

By sprinkling powdered salicylic acid on wounds till no more fluid passes out, Neudörfer manufactures a paste under which he says that healing may occur without suppuration.

II.—*Free Drainage as an Antiseptic Method.*

I have already discussed the main principles of drainage under the head of aseptic surgery. It is quite clear that, if discharge flows away as fast as it is formed, there can be no marked development of bacteria or of their products. The free drainage of a wound from which organisms are not from the first excluded is therefore of the utmost importance. I have already described the use of india-rubber tubes, and I have referred to catgut

and horse-hair. Since, in a wound not treated aseptically, fermentation, most probably followed by suppuration, generally occurs in the track of the drain, we must provide such a drain as shall permit the free escape of pus. Now, neither horse-hair nor catgut can drain pus, and, therefore, a tube of some kind or other must be used. This may be an india-rubber one, or it may be made of various kinds of metal, perforated at its sides, and cut flush with the surface. The tube, of whatever material, must be removed from the wound at each dressing and washed with a strong antiseptic lotion, say 1–20 carbolic lotion. If this be not done, portions of decomposing tissue, &c., remain inside the wound, and become more and more putrid till very soon they become caustic.

Where the wound is not treated aseptically, the principle of having the most dependent opening possible must be carried out to the full.

III.—*Irrigation and Immersion.*

The principle of free drainage is never of course used alone; other principles act along with it. Of these, one of the most satisfactory is that in which the discharge is not merely allowed to flow away, but is washed away, and the further addition to this principle of adding an antiseptic to the water used for the irrigation and of thus keeping the wound constantly bathed in an antiseptic fluid. The latter is the form in which irrigation and the water bath are now always employed, viz., by the use of an antiseptic solution.

Irrigation is, as a rule, only practicable on the extremities, though it may be carried out on the trunk. For the latter, however, the continuous water bath is the most convenient.

The wounded part having been arranged at perfect rest, a sheet of macintosh is fastened to the limb, and so arranged that the fluid flowing from the wound shall be conducted to a tub; the vessel containing the fluid is fixed at a considerably higher level than the patient. The form of irrigator most generally used at the present time is Esmarch's. This consists

of a cylindrical leaden or zinc vessel, which has a ring at its upper part to enable it to be affixed to the wall. From the side of this vessel, close to its bottom, a tube passes, and to the end of this tube is fastened a long piece of india-rubber tubing with a nozzle at its end. This nozzle is arranged so as to direct the fluid into the deeper parts of the wound. The fluid used is generally some weak antiseptic solution, such as chlorinated soda, or sulphurous acid, or boracic acid.

FIG. 48.—THIERSCH'S CHAMPAGNE BOTTLE IRRIGATOR.

A very good apparatus can be made in an emergency (according to Thiersch) by knocking the bottom out of a champagne bottle, and having the tube for conveying away the fluid passed through the cork. The bottle is inverted, filled with the solution, and fastened to the wall. The fluid used may be tepid or cold: there is no advantage in using it very cold, as recommended by some.

Where the fluid is dropped on to the wound, it is well to place a piece of lint over the part where the drop falls, to prevent the constant irritation caused by the concussion. The skin in the neighbourhood of the wound ought to be coated with palm oil, in order to prevent maceration.

The continuous bath is either a bath in which the whole patient can be immersed, or one in which the wounded part alone is placed. There are numerous methods of doing this, but I shall only refer to Langenbeck's and Valette's methods.

Langenbeck placed the wounds in the bath immediately after the operation. Where possible, he stitched up the wound, leaving a space at the angle through which discharges passed, and through which the ligatures were brought out. During the first twenty-four hours, the limb was simply suspended in

a bath, and was not arranged in a special apparatus which is apt to constrict the part and cause bleeding. When the edges could not be brought together, charpie and a bandage were applied for the first twenty-four hours to prevent bleeding.

The permanent bath was continued till granulation was complete, and till epidermic formation had commenced. The limb and granulations were apt to become œdematous, but this

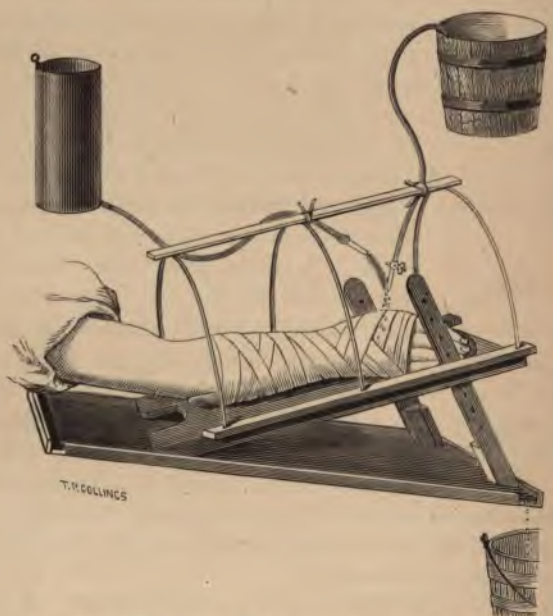


FIG. 49.—ARRANGEMENT FOR IRRIGATION IN THE UPPER LIMB.
(After Esmarch.)

subsided in a few hours after the removal of the part from the bath. The apparatus was emptied night and morning, and the walls of the vessel carefully sponged with water containing chlorinated soda or chloride of lime. When the stump had been closed at first, the wound was daily injected along the course of the ligatures. The temperature of the water was at

first 10°–12° C., but it was raised, as the patient could bear it, to 31°–37° C. The skin of the stump had a thick layer of grease over it, to prevent the action of the water on the epidermis. Where the whole body had to be immersed, the

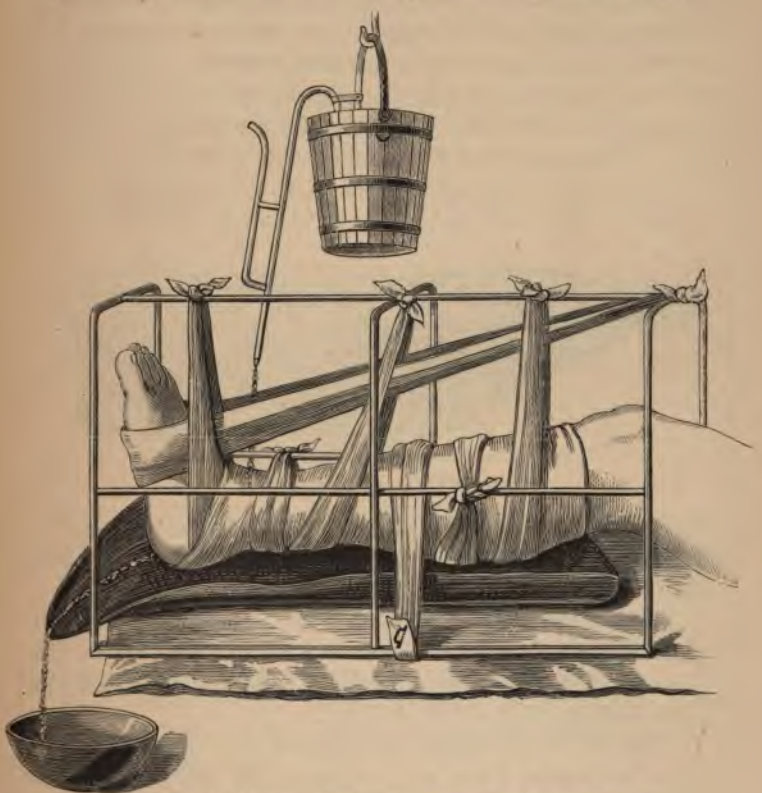


FIG. 50.—ARRANGEMENT FOR IRRIGATION IN THE LOWER LIMB.
(After Esmarch.)

immersion was continued for a half to one hour daily in water at the temperature of 34° C. Water dressing was employed towards the end of the case.

To avoid the dangers resulting from fermentation of the

fluid in the bath and in the wound, Valette impregnated the water with tincture of benzine, creosote, alcohol, or perchloride of iron. The last gave the best results. There was no putrefaction of this fluid, and he seems to have had great success. He was especially struck with the absence of traumatic fever.

The advantages of the treatment by constant irrigation are that the discharges are removed as fast as they form, and at the same time, where an antiseptic is employed, the part is kept constantly sweet. Thus, where the cavity is small and uncomplicated, there may be a truly aseptic state of affairs.

At the same time, where tepid water is used granulation is favoured, while pain and nervous irritation are very much

FIG. 51.—APPARATUS FOR CONTINUOUS IMMERSION.
(After Esmarch.) (For the extremities.)

diminished. Further, the parts are kept at absolute rest, the necessity of moving them in order to change dressings, &c., being avoided.

As an antiseptic means, I should think that satisfactory irrigation is better than the continuous water bath, for in the latter there is not the same constant change of fluid, nor the same washing away of the discharge.

The favourable results of constant irrigation, especially when antiseptic fluids are employed, in preventing septic diseases are very remarkable, and, in this respect, it probably stands next to strict aseptic treatment.

The disadvantages of these methods are for the most part the sodden state of the wound and the consequent œdematous condition of the granulations, the constant state of unrest of the wound and the inconveniences attending the application

of the method. For the first reason they are discontinued when granulation is complete and has filled up the deeper parts of the wound, and when the time for blood poisoning has passed.

That the good results of irrigation and immersion are not due to mere maintenance of temperature, as has been supposed, is shown by the results of M. Guyot with his incubation method. Here the wounded part was enclosed in an incubating apparatus, and kept permanently at a high temperature. This method, though much lauded for a time, really seems to have favoured considerably the development of septic diseases.

IV.—*Concentration of the Fluids and their Admixture with Oxygen.*

The method of treatment which has been the greatest stumbling-block in the way of the acceptance of the principles of antiseptic surgery is the open method, for surgeons have been unable to see how the success of this method could be reconciled with the germ theory of putrefaction. They have looked on it as the antithesis of aseptic treatment, as acting on the very opposite principle to that on which the aseptic method is based. And yet, when we come to consider the matter in the light of the true principles of antiseptic surgery, we find that the open method is an advanced method of antiseptic treatment. Of course other principles, such as that of perfect rest and free drainage, also tell markedly in this case.

I have stated that this open method acts antiseptically in two ways, and these I must now briefly consider.

1. It acts antiseptically in that the discharges dry up, and become more concentrated, and thus become unfit soil for the growth of bacteria.

That concentrated fluids are not suited for rapid development of organisms is well known. Thus Pasteur pointed out that organisms could not grow in sugary solutions which had become concentrated. This fact is made use of in the arts, in the preservation of fruits. Sugar is added in large quantities, and then the fruit can be kept for an indefinite length of time.

It is not that the sugar is an antiseptic killing the organisms, it is merely that by its presence in large amount the fluid is rendered unsuitable for development.

The same principle is made use of in preserving milk. The milk is evaporated to one-third of its original volume, and a considerable quantity of sugar is added to it. Without the addition of the sugar, the condensed milk may be kept for a considerable length of time without the appearance of organisms in it; with sugar it may be kept indefinitely.

The same is the case with other albuminous fluids, such as the discharge from wounds. Concentrate pus, and it will be found that organisms develop in it only with difficulty.

Then we know the contrast between cases of dry and moist gangrene; how in the latter putrefaction rapidly occurs, or, in other words, organisms rapidly develop, while in dry gangrene putrefaction does not occur, *i.e.* organisms cannot develop.

2. In the open method another antiseptic advantage is gained by the free admission of oxygen to the discharge.

Some very remarkable effects of oxygen in retarding putrefactive and other fermentations were published long ago by Pasteur. He pointed out that if a sugary solution were freely exposed to air in a thin layer, the yeast plant, though it grew luxuriantly, caused very little fermentation. On the other hand, if oxygen were excluded, only a small development of the yeast cells was necessary for fermentation. And he has shown that other plants besides the yeast plant can cause alcoholic fermentation, if only they are deprived of free oxygen.

With regard to putrefaction he has brought forward similar evidence. The organisms which cause putrefaction are, according to him, incapable of living in the presence of oxygen. If a putrescible fluid be freely exposed to the air in a thin layer, putrefaction does not occur, at least not for a very considerable time. Oxygen apparently not only interferes with the fermentative process, but actually destroys the bacteria which cause it. Hence the free exposure of a putrescible fluid to the air results in comparative freedom from putrefaction, partly because

the oxygen interferes with the development of fermentative changes, and partly because the oxygen directly kills the putrefactive bacteria.

There are two methods of wound treatment which act on the principles alluded to above. The first is that introduced by Bartscher and Vezin, and carried out in the following manner: 'After vessels have been tied, and after the stump has been cleansed from blood-clots by means of a sponge and cold water, the patient, for whom two beds are provided close to each other, is put to bed, the stump is laid on a soft pillow, and over it a piece of gauze or linen is loosely placed in order to keep out the flies, the whole stump being freely exposed to the air.' At the morning visit, the surgeon pushes his hand under the stump, raises it, removes the pillow and applies a new one, or lifts the patient on to the other bed, without further cleansing of the wound. In this method all attempts at union by first intention are given up.

Burow of Könisberg published his method in 1859. He attempted to obtain primary union as far as possible. This he did by bringing the surfaces of the wound into contact after a few hours by means of strips of plaster applied over part of the surface, all other dressings being avoided.

Rose, whose results of open treatment have been specially published by Krönlein, adheres to Bartscher and Vezin's method, with this exception, that he daily washes out the wound with some antiseptic lotion. Crusts are removed, as they are never complete enough to prevent putrefaction, and only cause tension by their presence, and indeed protect the discharge underneath from the action of the air, or of the antiseptic lotion. Rose further ventilates very freely, so as to have a plentiful supply of air to the stump. He employs this method in all wounds except those on the face, where union by the first intention is desirable.

The open method pure and simple is that introduced by Bartscher and Vezin; for here, while the discharges are allowed to flow away freely, they are left to the unaided action of the

air. The antiseptic effect of this method is no doubt increased by the addition of intermittent antiseptic irrigation.

Burow's method cannot act nearly so perfectly, for in it discharges must accumulate in various parts of the wound, and they are therefore not so conveniently placed for thorough action of the air.

Among the objections to these methods are the following: in all, except Burow's, union by first intention cannot possibly occur, indeed no attempt is made to obtain it; as a consequence of this, a long time is required for healing, while a larger scar is obtained; the frequent formation of scabs and the consequent tension also cause great annoyance.

Closely allied to the open method stands *healing by scabbing*. This may be brought about chiefly in two ways. The crust may either be allowed to form naturally, or its formation may be aided by artificial means.

This healing by scabbing acts in two ways. In the first place, the first principle of the open method of treatment comes into play; the discharge dries up and becomes an unfit soil for the development of organisms. In the second place the fluid underneath it is in such a thin layer that the living tissues in the neighbourhood prevent the development of organisms in it. Of course in many cases no living organisms would be there to develop, for the scab would form an absolute protection against their entrance.

The natural formation of the crust can only take place efficiently in small wounds, and only exceptionally where cavities and recesses are present. For in larger wounds, as we have seen, there is too much discharge for a sufficiently rapid and thorough formation of a crust; and if the crust is not perfect and rapidly formed, putrefaction takes place underneath it, while at the same time, by confining the discharges, tension and ulceration result in place of healing.

But though this natural formation of a crust cannot be trusted to in most cases, yet by artificial means a satisfactory one may be obtained.

Bouisson's method consisted in blowing air on to the surface of a wound by means of a caoutchouc bag. He generally directed the patient to do this himself. The 'ventilation' lasted a variable length of time, according to the extent of the surface and the quantity of fluid. A quarter of an hour generally sufficed for each *séance*, and this was repeated four or five times a day. The first crust which formed was rarely sufficiently thick or firm, but by-and-by the crust became of sufficient thickness, and when this was obtained, the ventilation was stopped. If the crust seemed to be confining the discharge and doing harm, it was softened and removed, and the process begun again.

The most common modes are by the application of various powders, such as starch, alum, flour, &c., to the discharge, so as to form a paste. One of the best substances which can be employed in this manner is powdered salicylic acid, as recommended by Neudörfer, and mentioned before under 'Treatment by Antiseptics.'

Neudörfer uses salicylic acid in the form of a powder mixed with other substances, such as starch, zinc oxide, &c. He dusts the wound with the powder, and rubs it up with the fluids of the wound. Thus a mass is formed, which is again rubbed up with fresh powder till no more fluid comes; then over the whole some pure salicylic acid is applied, and a bandage. This crust is left on, and if on pressure on it some fluid exudes, more powder is applied. This is generally necessary five or six times during the progress of a case. This method is really only of use in small wounds. The objections to its use in large wounds are that the pain is great, the material expensive and there is very apt to be confinement of discharge. Neudörfer states that there is no bad smell in the cases treated in this way. Among them he has had no bad case of pyæmia, hospital gangrene or tetanus. He cannot say much about erysipelas. As a rule, in the cases which were attacked, it was generally some other part of the body which was affected.

Other attempts have been made to produce a scab by the

application of various caustic substances to the surface of the wound. The crust so formed, containing as it does a strong caustic, is unable to undergo putrefaction; and where the inflammation caused by the application is not too great, and does not lead to accumulation of fluid under the crust, an excellent result is obtained. In this case, as no organisms are present under the crust (they were destroyed by the caustic), and as the firmly adhering crust prevents their entrance, we have the typical aseptic result—healing of an open wound without suppuration or granulation. There are, however, various objections to this method of crust formation, the chief of which is the loss of substance involved in the process, while the same disadvantages are present as in the open method proper, viz., slowness of healing and a large scar.

Closely allied to this method of crust formation is that in which the crust is obtained by the application of the actual cautery.

Crust formation is seldom suitable unless in the case of superficial wounds without recesses or cavities, for if these are present an opportunity is given for the occurrence of tension under the crust. It is a method by no means easy or universal in its application. Where it is employed I should recommend the use of Neudörfer's method, viz., the formation of a crust by the aid of salicylic acid powder.

Alphonse Guérin's Cotton-wool treatment acts partly on the first part of the principle of the open method, but it hardly comes into the category of antiseptic methods.

As originally used, the wound was simply washed with water, and a large mass of cotton wool applied around it, and firmly bandaged on.

At present the wound is washed with some antiseptic lotion, and layers of cotton-wool, containing camphor powder sprinkled in it, are applied. The deeper layer is of wool moistened in carbolic lotion. The dressing should not be applied or changed in the ward, but in a theatre or side room, and the packet of cotton-wool should not be opened till the time of application

of the dressing. No doubt these precautions may prevent some infective material present in the ward atmosphere from settling on the wound or on the cotton-wool, but it is only a chance that such will be the case.

This method can hardly be called 'antiseptic' in the sense in which we have used the word, for the anti-putrescent principles on which it acts are not very powerful. As the result of these dressings, the discharge becomes thick and concentrated, and not a very good medium for development of organisms. Nevertheless, this concentration of the discharge cannot occur to anything like the extent which takes place when it is left freely exposed to the air. The second principle on which it acts is that it insures absolute rest to the wound. By means of this rest the granulations are not lacerated, and bacteria and their products may thus be prevented from entering the body.

Guérin's method cannot be recommended except in some exceptional cases of disease of joints with sinuses, and even here the retention of the putrefying discharges, and the consequent irritation, render it of very doubtful value.

I have already described the aseptic applications of pure cotton wool at p. 121.

V.—*Assist the destroying Action of the healthy living Tissues on Bacteria.*

This principle may be aided in two ways, viz., by perfect mechanical rest, and by attention to the general health.

By perfect mechanical rest, when the tissues are in perfect health, and the blood-clot is undisturbed, the tissues and clot may be kept in such a state as to resist the development of organisms. This method, though without recognition of the antiseptic principle, has been long practised, and of late has been specially advocated by Mr. Sampson Gamgee.[1]

It is, of course, a well-known fact that, without any antiseptic appliances at all, wounds, more especially about the face, heal

[1] *On the Treatment of Wounds*, 1878.

frequently by first intention. How can this take place if blood or lymph, exposed to the air, putrefies as the result of the access of organisms? For, during the operation, organisms enter the wound both as dust from the air and surrounding objects, and also from the water in which the sponges are soaked. There is also between the cut surfaces a layer of blood or lymph (which, however, must as a rule be very small in amount, otherwise healing by first intention does not occur) which, if it were exposed between two plates of glass, would probably putrefy in a short time. How is it that union by first intention can occur under these circumstances? How is it that the blood does not putrefy between the cut surfaces of a wound?

Well, to use Sir Joseph Lister's forcible arguments, the *fact* is that a thin layer of blood, although containing numerous causes of putrefaction, does not as a rule putrefy if it be placed between two healthy living cut surfaces. Or, to state the fact in another way, these organisms, which are certainly present, cannot develop in a thin layer of blood or lymph placed between two healthy living freshly cut surfaces. Or, to state the same fact differently (taking into consideration the different results when the same layer of blood or lymph is placed between two plates of glass), the *living tissues, when in a healthy state*, have the power of preventing the development of organisms in their immediate vicinity.

That healthy blood-clot can resist putrefaction so long as it is kept at rest explains many remarkable cases which would otherwise seem at first sight at variance with antiseptic principles. The following case, showing the contrast between blood-clot when kept at rest and when disturbed, is worth narrating.[1]

'On September 15, 1870, a young officer whose left upper arm had been broken about its middle by a Chassepot bullet at Noisseville seventeen days previously, arrived with an ambulance train at the Tempelhof military hospital.

[1] Esmarch, Langenbeck's *Archiv*, vol. xx. p. 169.

'The plaster of Paris apparatus, which had been applied at once on the battle-field, had become soft and broken, and as the patient complained of pain in the arm, probably as the result of the journey, and as it was somewhat swollen, the apparatus was removed, and a careful examination was made of the wound. When I passed my finger into the wound after removal of the crust, I felt numerous fragments of bone, but was, however, astonished to find *no trace of pus, only coagulated blood*.

'After I had removed all the fragments, a plaster apparatus with a window in it was applied; nevertheless, there now resulted a *violent inflammation and suppuration of the wound*, which for a time threatened the young man's life.'

These views sufficiently reconcile the fact of union by first intention in cases not treated aseptically with the germ theory of putrefaction.

Now in order to have tissues in the state in which they are capable of resisting the development of bacteria in their immediate vicinity, they must be as much as possible in a condition of perfect health. To attain this, the health of the patient must be attended to and kept good, and all causes which irritate and cause the wounded part to inflame or become weaker must be avoided. The causes which weaken the part are various forms of unrest, mechanical or chemical.

To carry out this principle two things are required, viz., accurate approximation of the cut surfaces, and absolute immobilisation of the part. Where accurate approximation of the cut surfaces cannot be obtained, the same principle of absolute rest must be carried out as regards the clot filling up the gap, and it may thus resist the development of bacteria in its substance. Were I compelled to treat any case on this principle alone, I should combine with it the open method, leaving the wound freely exposed to the air. The superficial layer of the clot, by drying up, would thus to some extent form an obstacle to the entrance of organisms.

I have mentioned this as an antiseptic method, as the

principle is of great importance in explaining certain otherwise puzzling cases, but I should not recommend it for adoption, for it is only in a few cases, such as in face wounds, where the vitality of the part is high, that this vital action of the tissues and blood-clot can be sufficiently trusted.

Such are the chief principles on which antiseptic surgery can be carried out. In the class of antiseptic methods to which I have referred in this chapter, the surgeon does not adhere strictly to one or other principle, partly because the principles on which he acts have not as yet been properly understood or appreciated, and partly because better results can be obtained by their combination.

In many minor ways the antiseptic principle may be aided. Thus by the use of catgut ligatures, we do not have a long septic thread hanging out of the wound, conducting putrefaction into its interior and leading to deep-seated suppurations, &c.

The silver suture acts in the same way as compared with the silk. Silver does not absorb the putrescible materials, and thus putrefaction does not occur in it. On the contrary, silk absorbs blood and serum, which putrefy in it, and the silk, which was at first unirritating, becomes very acrid and causes inflammation in its vicinity.

What are the various means by which the general health and tone are kept up in septic cases, what is the careful selection of healthy individuals for operation, but imperfect attempts at antiseptic surgery?

What is ventilation but an antiseptic means? The air being constantly changed, the foul emanations from wounds containing septic bacteria are diluted and swept away, while at the same time a better state of health is obtained.

And so I might go on enumerating various minute points which have been, in ignorance of their true significance, adopted in the treatment of wounds, all of which act, more or less, on and promote antiseptic principles.

INDEX.

ABD

Abdomen, wounds of, aseptic treatment of, 98
Abscesses, after-treatment of, 94
— aseptic drainage of, 93
— — dressing of, 94
— — treatment of, 91
— bacteria and, 17
— formation of, 9, 19
— lumbar, 86
— near anus, aseptic treatment of, 95
— of hip joint, 86
— perineal, aseptic treatment of, 94
— psoas, 83
— retropharyngeal, aseptic treatment of, 92
— spinal, recumbent position in, 94
— thoracic. *See* Empyema, 94
— when and where to open, 84, 92
Accidental wounds, 95
Acetate of alumina, 116, 121
Acute necrosis, 9
— osteomyelitis, 9
— spreading gangrene, 22
Air, filtration of, through cotton-wool, 121, 124
Alcohol as an antiseptic, 127
— — — — Hutchinson on method of using, 127
Anal abscess, aseptic treatment of, 95
Antiseptic methods, 142–145
— — free drainage, 130
— — irrigation and immersion, 130–134
— — open method, 135–138
— — rest, 143
— — ventilation, 145
Antiseptics. *See* Disinfectants
— treatment by, explained, 33, 125, *et seq.*
Arrangement of towels, 52
Arteries, ligature of, 54

ASE

Aseptic operation, 46–50
— — duties of dresser in, 50
— — errors in, how corrected, 49–53
— — example of, 46–50
— — ligature of vessels in, 55
— — use of carbolised towel in, 46, 51
— — use of guard in, 54
— surgery, defined, 36
— — materials employed in, 36, *et seq.*
— — principles of, 36
— treatment in country practice, 103–106
— — in war, 106–111
— — of abscess, 91
— — of accidental wounds, 95
— — of burns, 100
— — of compound fractures, 97
— — of compound fractures of skull, 97
— — of contused wounds, 96
— — of dissection wounds, 102
— — of gangrene, 101
— — of gunshot wounds, 106–111
— — of wounds of abdomen, 98
— — of wounds of intestines, 98–99
— — of wounds of joints, 97
— — of wounds of muscles, 97
— — of wounds of nerves, 97
— — of wounds of tendons, 97
— — of wounds of thorax, 98
— — substitutes for carbolic acid in, 112–129
— — use of acetate of alumina in, 116
— — — of eucalyptus oil in, 117
— — — of iodoform in, 120
— — — of salicylic acid in, 113–116
— — — of thymol in, 116
— wounds, 36, *et seq.*
— — drainage of, 56
— — stitching of, 65, 96

ASE

Aseptic wounds, strapping of, 67
— — use of cotton wool, 121–123
Axilla, aseptic dressing of, 78–82

Bacilli. *See* Bacteria, 11
Bacillus anthracis, 25–26
Bacteria and abscess, 17
— — acute osteomyelitis, 20
— — carbolic acid, 25
— — disease, 14–24
— — erysipelas, 21
— — gangrene, 22
— — healthy tissues, 141, 144
— — heat, 32
— — inflammation, 17
— — phagedæna, 22
— — pyæmia, 23
— — septicæmia, 23
— — septic intoxication, 15
— — spontaneous generation, 13
— — suppuration, 16
— — traumatic infective diseases, 14
— classification of, 11
— Becker and Krause on, 20
— Bergmann's experiments on, 15
— cultivation of, 13
— description of, 11–14
— destruction of, 25, 32
— — of by healthy tissues, 141–144
— diseases caused by, 14–24
— Fehleison on, 20
— Fischer on, 31
— general description of, 11
— growth of, 12
— how to assist tissues to destroy, 141–144
— Koch on, 25
— life history of, 12
— Lister, Sir J., on, 120, 142
— mode of growth of, 12
— of blue pus, 25
— Panum on, 15
— poison produced by, 15
— products of, 14
— Schill on, 31
— spores of, 25
— temperature necessary to destroy, 32
— vitality of various, 26
— why they do not always cause fermentation, 142
Bandage, carbolic gauze, 43, 67
— elastic, 71
— muslin, 70
Bandaging of gauze dressing, 70

CHI

Barker, Mr., on filtration of air, 123
Bartscher and Vezin's open method, 138
Becker on bacteria, 20
Bergmann's experiments on bacteria, 15
Bichloride of mercury, 29, 119
— — — Bruns, Von, on, 119
— — — Lister, Sir J., on, 120
— — — Schede's results, 119
Blood-clot at rest and disturbed, contrasted, 143
— healing by organisation of, 4, 5
Bone, death of, 8
— decalcified tubes, 116
Boracic acid lint, 44
— — lotion, 44
— — ointment, 44
— lint dressings, changing of, 75
— — — use of, 75
— — wet in place of poultice, 76
— ointment as a dressing, 75
Bouisson's method of crust formation, 139
Bright's disease, operating in, 16
Bruns, Von, on bichloride of mercury, 119
Burns, aseptic treatment of, 100
Burow's open method, 137
Button stitches, 65
Buttons, lead, for deep stitching, 65

Capillarity, drainage by, 60
Carbolic acid, Lemaire on use of, 129
— — oily solutions of, 37
— — poisoning, 126
— — solution of, in glycerine, 38
— — substitutes for, 112–129
— — undiluted, 37
— — use in treatment by antiseptics, 125–128
— — watery solutions of, 37
Carbolised catgut, 40
— gauze, 43
— silk, 41
— wool, 45
Catgut, carbolised, 40
— — chromic (Lister's), 40
— chromic (MacEwen's), 64
— drainage by, 60
— Lister's pocket holder, 41, 42
— trough for, 41
— use as a ligature, 40, 55
Chassaignac's drainage tubes, 56
Chiene on catgut drains, 60
— — retropharyngeal abscess, 92

CHI

Chiene on situation of opening in psoas abscess, 85
Chloride of zinc, solution of, 45–126
Chlorinated soda, 127
Comparison of course of simple and compound fractures, 8
Compound fracture, aseptic treatment of, 97
— — course of, 8
Conservative surgery, bearing of aseptic treatment on, 109
Contused wounds, aseptic treatment of, 96
Cost of aseptic treatment, 103, 106
Cotton wool, A. Guérin's dressing, 140–141
— — aseptic use of, 121–124
— — carbolised, 45
Country practice, aseptic treatment in, 103–106
— — mode of dressing in, 103–106
Cream, salicylic acid, 44
Crust, Bouisson on, 139
— formation of, 2–7, 138–140
— healing by, 2
— Neudörfer on, 139
— treatment by, 138–140

Dangers following wounds, 8
Decalcified bone tubes, 64
Definition of aseptic surgery, 36
Degeneration, waxy, 9
Disinfectants, 25
— acetate of alumina, 116
— alcohol, 127
— bichloride of mercury, 29, 118, 119
— boracic acid, 126
— carbolates, 27
— carbolic acid, 25, 28, 112–129
— — oil, 28
— chlorinated soda, 127
— eucalyptus oil, 117
— iodoform, 120
— Koch's experiments on, 25
— Lister, Sir J., on, 118
— naphthalin, 120
— Neudörfer's salicylic powder, 129
— salicylic acid, 112
— — powder, 129
— sanitas, 129
— Schulze on, 117
— sulphurous acid, 127
— terebene, 129
— thymol, 116
— varicus, 30

EMP

Dissection wound, aseptic treatmen of, 102
Drain, catgut, 60, 63
— horsehair, 63
— — re-introduction of, 63
Drainage as an antiseptic method, 56
— aseptic, of abscess, 93
— by capillarity, 60
— — catgut, 60, 63
— — Chassaignac's tubes, 56
— — decalcified bone tubes, 64
— — horsehair, 63
— — india-rubber tubes, 56
— Chiene's method of, 60
— importance of, 56
— of aseptic wounds, 56
— tubes, absorbable, 60–62, 65
— — position of, in aseptic wounds, 57–59
— — use of, 56
Drains absorbable, 60–62, 65
Dressing, aseptic, axillary, 78–82
— boracic, 44, 75–76
— breast (three methods), 78–82
— changing of, 71–73
— deep, 68
— errors in use of protective, 67–68
— excision of joints, 39
— fixing of, 70–71
— general gauze, 43, 47, 69
— loose gauze in, 43, 47, 69
— lumbar abscess, 83
— method of changing, 72–73
— neck, 78
— of hernia, 86
— of hip-joint abscess, 86
— of limbs, 83
— ovariotomy, 91
— psoas abscess, 83
— scalp, 77
— scrotum, 86
— time of changing, 71–72
— use of pins in, 47, 70–71
— — of protective in, 67
— — of wet gauze in, 47, 68–69
— water, 8, 100
Dressings, aseptic, in country practice 105–106
— — permanent (Neuber's), 116
— — use of sponges in, 43–44
— — with salicylic acid, 44, 113

Elastic bandage, 71
Empyema, 94
— aseptic treatment of, 94

ERR

Errors in aseptic operations, how avoided, 49
Erysipelas, 9
— micro-organisms of, 20
Esmarch's arrangement for irrigation, 131
Eucalyptus gauze, 118
— oil, Bucholtz on, 117
— — Schulz on, 117
— — Siegen on, 117
— ointment, 118
— — in burns, 118
Example of aseptic operation, 49
Excision of joints, aseptic dressing of, 39
Experiments on disinfectants, 25

FERMENTATION, cause of, 6, 33, 34
— chemical, 6
— in wounds, 33
— Pasteur on, 136
Fever, hectic, 9
— traumatic, 9
First intention, healing by, 2
Fischer on naphthalin, 120
Forceps, sinus, 59
Fractures, compound, 8, 97
— simple, 8
Free drainage, 35

GANGRENE, acute spreading, 22
— aseptic treatment of, 101
— Koch's experiments, 22
— pathology of, 22
— senile, 101
— traumatic, 9
— treatment of, 101
Gauze, carbolic, bandage, 43, 67
— — — use in deep dressing, 69
— — general dressing, 43, 47, 69
— — loose, 43, 47, 69
— dressing, how to make a, 69
— eucalyptus, 118
— sublimate, 119
— thymol, 116
Granulation, healing by, 3
Granulations, healing by union of, 3
Guard, use of, in aseptic operations, 54
Guérin, Alphonse, on cotton wool, 140, 141
Gunshot wounds, aseptic treatment of, 106–111
Guyot, results of his incubation method, 135

LIS

HACK, Dr., on absorption from wounds, 127
Hands, purification of, 48
Healing by first intention, 2
— — granulation, 3
— — organisation of blood-clot, 4
— — scabbing, 2, 138–140
— — union of granulations, 4
Hernia, aseptic dressing of, 86
Hip joint, aseptic dressing of abscess of, 86
Horsehair drains, 63
— — re-introduction of, 63
Hutchinson on method of treating wounds, 127

IMMERSION, treatment by, 130–135
India-rubber drains, 56
Inflammation, absence of, in aseptic wounds, 28
— bacteria and, 16
Injuries, repair of, 1–8
Instruments, purification of, 49
Intestines, wounds of, aseptic treatment of, 98
Intoxication, septic, 9, 15
Iodoform, 45, 120
Iron, perchloride of, as a disinfectant 132
Irrigation and immersion, 130
— as an antiseptic, 130
— Esmarch's arrangement for, 131
— Langenbeck and Valette's methods of, 132
— treatment by, 35
Irrigator, Thiersch's, 131

JOINTS, excision of, 39
— wounds of, treatment of, 97
Jute, salicylic acid, 114

KOCH on bacteria, 25
— — gangrene, 22
— — traumatic infecti ve diseases, 18, 21, 23

LIGATURE of vessels with catgut, 40, 55
Limbs, aseptic dressing of, 83
Lint, boracic, 44
Lister, Sir J., on aseptic treatment in war, 106
— — — — use of corrosive sublimate, 119

LIS

Lister, Sir J., on cotton wool, 121
— — — — destruction of bacteria by healthy tissues, 142
— — — eucalyptus oil, 118
Lotion, boracic, 44
— carbolic, 37
Lumbar abscess, aseptic dressing of, 86

Maas on acetate of alumina, 116
MacEwen's absorbable drainage tubes, 65
Mackintosh, use of, in gauze dressing, 43
Mamma, dressings after operations on, 78–82
Mechanical exclusion of dust, 121, 124
Melladew on aseptic treatment in war, 111
Micrococci. *See* Bacteria, 11
Micrococcus prodigiosus, 25
Muscles, wounds of, aseptic treatment of, 97

Nævi, treatment of, 102
Naphthalin, 120
Necrosis, 9
Nerves, wounds of, aseptic treatment of, 97
Neuber's absorbable drainage tubes, 64

Objections to aseptic treatment, 103
Oiled silk, 42
Ointment, boracic, 44
— eucalyptus, 76
— salicylic, 45, 75
Open method of treatment, 35, 135
Operation, aseptic, duties of dresser in, 50
— example of, 46
— — — illustrated, 50
— ligature of vessels, 55
— probable errors in, 49
— spray in, 50
— towels in, 52
— use of guard in, 54
Organisation in blood-clot, 5
— of dead tissue, Tillmanns on, 4
Osteomyelitis, 9
Ovariotomy, aseptic dressing of, 91
Oxygen and bacteria, 12, 14, 135
— — — Pasteur on, 136, 137

SAL

Pasteur on fermentation, 136
— — organisms, 122, 136, 137
Pathology of gangrene, 22
Perineum, aseptic treatment of abscess of, 94
Periostitis, cause of, 9
Phagedæna, 9
Pigment formed by bacteria, 14
Pins, use of, in gauze dressing, 47, 70, 71
— — — precautions in, 70, 71
Poisoning with carbolic acid, 126
Precautions in operations, 49–51
— spray least necessary of, 53
Principles of aseptic surgery, 36
Probable errors in aseptic operation, 49
Processes of repair of injuries, 1–8
Protective, errors in use of, 67–68
— preparation of, 47
— use in aseptic dressing, 47, 67
Psoas abscess, aseptic course of, 91–94
— — dressing of, 83–6
— — situation of incision, 83–85, 92
Purification of hands, 48
— — instruments, 49
— — recent wounds, 95–96, 103
— — septic wounds, 74, 75, 95–96, 103
— — skin, 46, 48
Putrefaction, dangers of, 8
— theories of. *See* Fermentation, 6, 33, 34, 136
Putrefactive fermentation, 33, 136–137
Putrid wounds, 99
Pyæmia, relations to fermentations in wounds, 9, 23

Ranke on thymol, 116
Rest as an antiseptic, 35, 141, 144
— fundamental principle of wound treatment, 141–144
Results of A. Guérin's dressing, 141
— — antiseptic surgery, 28, 109–111
— — aseptic treatment, 28, 91, 109–111
— — irrigation, 132–135
— — occlusion, 107–110
— — open method, 136–138
— — water bath, 132–135
Retropharyngeal abscess, 92
Reyher on aseptic treatment in war, 109
Rose's open method, 137

Salicylic acid, aseptic use of, 112
— — cream, 44

SAL

Salicylic acid, dressings with, 111, 112-116
— — jute, 105, 113
— — lotion, 112
— — ointment, preparation of, 45
— — — uses of, 44
— — wool, 113
Sanitas, 129
Scabbing, healing by, 2, 138–140
Scalp, aseptic dressing of, 77
Schede on iodoform, 121
— on bichloride of mercury, 119
Schulz on eucalyptus oil, 117
Scrotum, aseptic dressing of wounds of, 86
Sepsin, 15
Septic intoxication, 9
— — causes of, 15
— treatment, results of, 15
— wounds, purification of, 74, 75, 95-96, 103
Septicæmia, 9
Silk, carbolised, preparation of, 60
Silver wire stitches, 66
Sinus forceps, 59
— putrid, treatment of, 99
Skin, purification of, 46, 48
Skull, compound fractures of, aseptic treatment of, 97
Sloughing, 9
Soda, chlorinated, as an antiseptic, 127
Spinal abscess, 94
— — recumbent position in, 94
Spirilla. *See* Bacteria
Spirochætæ. *See* Bacteria
Sponges, purification and preservation of, 44
— use of, in dressings, 71
Spontaneous generation, no experimental fact known in favour of, 13
Spoons, Volkmann's sharp, 99
Spores, carbolic acid and, 25
— experiments on, 26
— formation of, 12
Spray, carbolic acid, as germicide, 28
— errors in use of, 53
— how to dispense with, 103–106
— one of the least necessary precautions, 53
— producers, hand, 38
— — steam, 39–40
— use of, 38, 53, 73
Stitches, button, 65
— of coaptation, 66
— of relaxation, 66
— removal of, 67

VES

Stitching of aseptic wounds, 65
Strapping of aseptic wounds, 67
Streptococci, 22
Subcutaneous surgery, 124
Substitutes for carbolic acid, 112–129
Sulphurous acid as an antiseptic, 127
Suppuration, causes of, 17
— not always due to micro-organisms, 16
Surgery, aseptic, definition of, 36
— — materials employed in, 36
— — principles of, 36–37
Sutures, 65

Temperature necessary to destroy bacteria, 32
Tendons, wounds of, 97
Thiersch on salicylic acid dressings, 112
— — irrigator, 131
Thorax, wounds of, 98
Thymol, aseptic use of, 116
Tillmanns on organisation of dead tissue, 4
Tissue, healthy, resists bacteria, 141–144
Towel, carbolised use of, in aseptic operations, 52
Traumatic gangrene, 9
— fever, 9
— infective diseases, 18, 21, 23
Treatment, antiseptic, explained, 33
— aseptic, 46
— by perfect rest, 35, 141, 144
— Listerian, 35
— of abscesses, 78, 83, 86
— of accidental wounds, 95
— of gangrene, 101
— of nævi, 102
— of putrid sinuses, 99
— of ulcers, 74
— of varicose veins, 102
— open method of, 35, 135

Ulcer, purification of, 74
— treatment of, with boracic acid, 74–75
Union of granulations, healing by, 4

Ventilation as an antiseptic means, 145
— of wounds, 139
Vessels, method of tying, in dense tissues, 55

VEZ

Vezin and Bartscher's open method, 137
Volkmann's sharp spoons, 99

War, aseptic treatment in, 106–111
Water dressing. *See* Dressing
Waxy degeneration, 9
Wool, cotton, aseptic use of, 120–124
— Guérin's, 140–141
— salicylic acid, 113
Wounds, accidental, aseptic treatment of, 95
— antiseptics in, 16
— aseptic treatment of. *See* Aseptic
— bacteria in, 10–24
— causes of irritation in, 6, 16
— contused, 96
— course of, outline of, 1–8
— dangers following, 8
— dissection, aseptic treatment of, 102
— drainage of, 56
— fermentation in, 33
— Gamgee, Mr. S., on treatment of, 142

ZOO

Wounds, gunshot, aseptic treatment of, 106–111
— how to keep aseptic, 36
— mechanical exclusion of air from, 120–124
— micro-organisms in, 10–24
— of abdomen, aseptic treatment of, 98
— of intestines, aseptic treatment of, 98
— of joints, aseptic treatment of, 97
— of muscles, aseptic treatment of, 97
— of nævi, aseptic treatment of, 97
— of parietal pleura, aseptic treatment of, 98
— of skull, aseptic treatment of, 97
— of tendons, aseptic treatment of, 99
— of thorax, aseptic treatment of, 98
— processes of healing of, 1–8
— purification of, 74, 75, 95, 96, 102, 103
— putrid, 99
— stitching of, 65, 96
— strapping (aseptic) of, 67

Zinc, chloride of, 45
— sulphocarbolate of, 27
Zooglæa. *See* Bacteria, 12

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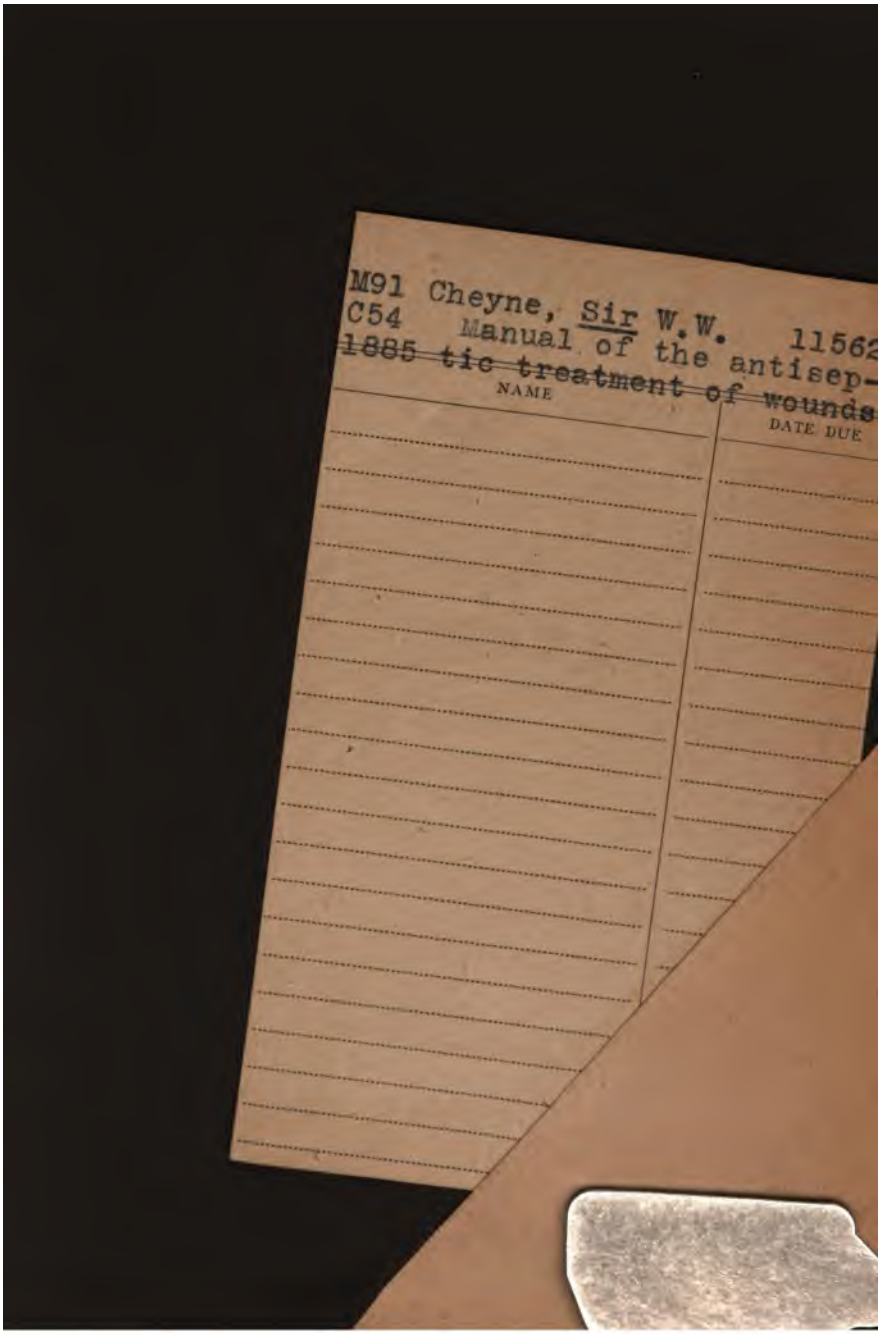
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